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ON A THEOREM OF RANKINE RELATING TO THE ECONOMY OF SINGLE ACTING EXPANSION ENGINES, FIRST PUBLISHED IN 1851.

By PROFESSOR W. P. TROWBRIDGE.

[Read (by title) at the meeting of the American Society Mechanical Engineers, at Philadelphia.]

The object of the theorem above referred to was, in the words of the author, "to investigate and explain the method of determining the rate of expansion, and consequently the dimensions and proportions of a Cornish engine which, with a given maximum pressure of steam in the cylinder, at a given velocity, shall perform a given amount of work at the least possible pecuniary cost, taking into account the expense of fuel and the interest of capital required for the construction."

He further states, as a fundamental proposition, that "by increasing the ratio of expansion in a Cornish engine the quantity of steam required to perform a given duty is diminished and the cost of fuel and of the boilers is lowered. But, at the same time, as the cylinders and every part of the engine must be made larger to admit of greater expansion the cost of the engine is increased."

"It thus becomes a problem of maxima and minima to determine what ratio of expansion ought to be adopted, under given circumstances, in order that the sum of the actual cost of fuel and interest of the capital employed in construction may be the least possible as compared with the work done."

It is somewhat remarkable that this theorem is nowhere alluded to in the author's subsequent elaborate treatise on the steam engine; while on the other hand he was the first to formulate in that treatise, definitely, the true theory of the efficiency of the steam in the cylinder of an engine, and to explain how the combined efficiencies of the boiler, engine and mechanism are to be ascertained from a purely mechanical and theoretical point of view. During the thirty years that have elapsed since the publication of the theorem, its value or importance, if either can be attached to it, have been ignored not only by all eminent writers on the steam engine, but by those most interested, the designers and users of steam engines.

It is reasonable to suppose, from these circumstances, either that there is an inherent fallacy in the theorem itself, or that engineers and business men have found it to be, even if true as a mathematical proposition, inapplicable in designing engines, or in using them.

An apology ought to be offered for asking the further time and attention of this Society to a subject upon which there can be very little difference of opinion among well informed engineers, as far as its theoretical aspects are concerned; but in the recent renewal of the discussion, upon the basis of this old theorem of Rankine, such positive grounds are taken in regard to the necessity of a radical change of views and of practice among engineers concerning the proper method of ascertaining the conditions of maximum economy in the application of steam-power, that a thorough criticism of the new methods seems to be called for. In order to do this it is necessary to enunciate the theorem in its mathematical form.

Let p_e represent the mean effective pressure in the cylinder of an engine per square foot of piston, and V_2 the volume in cubic feet generated by the piston in one hour; then $p_e V_2$ will represent in foot-pounds the work per hour of the weight of steam admitted to the cylinder. Let W represent this weight and h^1 the cost of producing it, including the cost of fuel and the hourly interest on the cost of the boilers; then $\frac{h^1}{W} = h$ will be the cost of producing one pound hourly.

Let K^1 represent the total interest on the cost of the engine, A the area of the piston, and K the interest per hour of the cost of the engine per square foot of the piston, then

$$K^1 = K.\,A.$$

The assumption made is, that the work in foot-pounds divided by the cost of the work must be a maximum for greatest economy; that is, if y be this ratio

$$y = \frac{p_o V_2}{h.\,W. + K.A.} \text{ must be a maximum.}$$

Let l represent the length of stroke, n the number of revolutions per hour, r the ratio of expansion, then

$$W = \frac{A.l.n}{r}\,.\,D$$

D being the weight of a cubic foot of steam at the initial pressure.

The above expression then becomes

$$y = \frac{p_o V_2}{h\,.\,\frac{A.l.n}{r}\,.\,D + K.A\,.}$$

$$= \frac{A.l.n\left[\frac{p_1}{\gamma - 1}\left(\frac{\gamma}{r} - \frac{1}{r^\gamma}\right) - p_2\right]}{h\,.\,\frac{A.l.n}{r\,v_1} + K.A.}$$

r only being supposed variable in the second member, and in which p_1 is the initial pressure γ, the exponent of v in the equation of the adiabatic curve of expansion, $pv^\gamma = p_1 v_1^\gamma$ = constant, and p_2 the back pressure.

The result of the operation for finding the maximum of y by the calculus is an equation between the values of V_2, K, h, A and r, as follows, supposing y to be be $\frac{10}{9}$

$$h\,\frac{A.l.n}{v_1}\left(p_1 r^{-\frac{10}{9}} - p_2\right) = K.A\left[p_1\,10 - 10 r^{-\frac{1}{9}}\right]$$

This result and the former expressions will be recognized as those given in a paper read at the Hartford meeting of the Society by Messrs. Wolff and Denton, as being substantially the same as those

of Rankine. In this expression v_1 represents the value of one pound of steam at the initial pressure p_1, and $\frac{1}{v_1} = D$, D being the weight of a cubic foot of steam at the same pressure.

The usual mode of stating the efficiency of the steam in the cylinder of an engine is

$$E = \frac{p_o V_2}{H \cdot \frac{A\,l\,n}{r} D \cdot \times 772}$$

In this expression no element of cost enters, but the denominator represents the number of foot-pounds of work which enters, *as heat*, into the cylinder each hour.

H being the heat of evaporation, $\frac{A.l.n}{r} D$ the weight W, and 772 the dynamic equivalent of a unit of heat. The maximum of this expression corresponds to such a degree of expansion by the adiabatic curve that the terminal pressure in the cylinder is just equal to the back pressure p_2. *The maximum of* y will correspond to a less degree of expansion, or to more steam used in proportion to the work developed.

The work $p_2 V_2$ for any degree of expansion may be represented by a rectangle of which the base is V_2 and the altitude p_o. The denominator may also be represented by a rectangle having the same base, but with a much greater altitude. The efficiency E is the ratio of these rectangles, or what is the same thing, the ratio of the altitudes of the rectangles. A somewhat similar process may be applied to the ratio giving the value of y, as explained by Rankine and worked out for varying values of the mean effective pressures and for various engines and boilers by Messrs. Wolff and Denton in the paper above referred to.

The graphical process thus introduced by Rankine shows at once the ratio of expansion which gives the maximum of y, or the rate of expansion which gives the greatest number of foot-pounds for the least amount of money, according to the author, *when his assumed premises are accepted.*

In regard to the maximum of E, the mechanical efficiency, a discussion by Rankine, found in his work on the steam engine, is a legitimate and correct one, but the theorem which introduces the cost is, at

least when applied to modern steam engines, fallacious, inasmuch as the *premises assumed are not true.* It is a very ingenious discussion, considered as a mere mathematical problem, admitting all the assumptions; but if these assumptions are not correct it must be considered, as it is practically, mere play of mathematics without practical value. In this presentation of the matter, from a purely theoretical standpoint, the secondary influences of cylinder condensation, clearance, etc., are not considered.

The first false assumption is in the total cost of making steam per hour, $h.W.$ h is a constant, and is the cost of evaporating one pound of steam, including interest on cost of boiler; and when multiplied by the weight W it is assumed that the cost of a boiler constructed to evaporate this quantity of steam varies with the quantity of steam produced.

Whereas it is well known that the *same boiler* will produce more or less steam depending simply on the draft, and upon other circumstances not introduced. No exact relation of a general nature exists between the cost of a boiler and the quantity of steam it produces. Moreover, the chimney, or other appliance for producing draft, is an essential part of the boiler, and its costs should be included in the cost of making steam. The relation of cost to the quantity of steam produced is thus still more uncertain.

In the discussion of Rankine's theorem, by Messrs. Wolff and Denton, and by Prof. Thurston, who adopts and endorses their discussion, the quantity h is made to include also hourly wages of firemen, coal-passers, interest, a redemption annuity, or sinking fund, for the whole *supposed* lifetime of the boiler, etc.

This accumulated quantity h, multiplied by the weight of steam used at different grades of expansion, is taken at the hourly cost of making the quantity of steam W. It is hardly necessary to dwell on the fallacy of these assumptions, as the error must be apparent from the above statement, which will hardly be denied by those conversant with steam apparatus.

The second false assumption is in making the total cost of an engine proportional to the area of the piston.

The value of K in the formula is the interest on the cost of the engine divided by the area of the piston. It is well known that the cost of modern steam engines does not vary as the piston area, nor as the volume of the cylinder.

The following statement, taken from the yet unpublished records of the Tenth Census, has been furnished me by Mr. Charles H. Fitch, special agent of the census, who has been engaged under my direction in determining the statistics of engines and boilers.

Cylinder Capacity and Cost.

"The following table exhibits comparatively the relations of cylinder capacity, weight and cost in steam engines of the horizontal plain slide valve type, rated at from eight to one hundred horse-power:

Cylinder Capacity of Engine	Ratio of stroke to diameter.	Price per cubic foot of cylinder.	Weight of engine per cubic foot of cylinder (lbs).
0·19	2·00	$1,910 00	8,684
0·27	1·71	1,392 00	6,296
0·46	2·00	1,113 00	7,500
0·59	1·77	952 00	7,118
0·72	1·60	872 00	6,944
0·90	2·00	749 00	6,264
1·31	1·66	707 00	6,183
1·58	2·00	644 00	5,860
1·79	1·43	633 00	5,168
2·14	1·71	569 00	5,023
2·79	1·50	497 00	4,337
3·48	1·87	451 00	4,253
3·53	1·33	509 00	5,241
4·41	1·66	448 00	4,736
4·35	1·20	517 00	4,638
5·44	1·50	459 00	4,964

"It is obvious that no formula can truly exhibit the relative changes of price and capacity, which does not consider the actual sizes of engines

compared. The examples cited present an unusual degree of uniformity, a line of engines rated at uniform piston speed, and of similar excellent workmanship and finish.

"Between different styles and qualities of engines there can be no very definite comparison. For the same cylinder capacity a finely built, closely fitted engine may cost twice as much as an engine of inferior workmanship."

Rankine evidently assumed that the cost is proportional to the volume of the cylinder or to piston area, because this is the only assumption that will enable an engineer to *design an engine with a given power*, the steam being cut off at the point of the stroke determined by his theorem.

He gives an example by designing an engine of 100 HP, having first found the proper ratio of expansion for a cylinder having a unit area of piston and a given speed. He finds the cost of a 100 HP engine of the same speed to be by his process £6018, an assumed cost of £250 per square foot of piston. Of course, if his 100 HP engine, with all its appliances, was found, when actually constructed, to cost more or less than £6018 the whole process becomes invalidated.

It would seem that nothing more need be said to exhibit the fallacy of the assumptions or premises on which the mathematical work of the whole discussion is based. But we may place these fallacies on broader grounds.

There cannot be, from the nature of finance and pure mechanics, any exact mathematical relation between abstract mechanical laws and financial operations.

The former are invariable and immutable, the latter are dependent upon bargain and sale, the efficacy of human labor or upon human necessities, and sometimes on human follies.

No more conspicuous illustration of these truths, it seems to me, could be given than this plausible, but false application of mathematics, and especially of the calculus, to a problem in which the cost of an apparatus and its mechanical performance are introduced as elements of a formula which is claimed to be general in its nature and practically correct in its applications.

Looking at Rankine's theorem from another point of view it is claimed that although it is not applicable *for designing engines*, yet after an engine and boiler have been completed, and the actual cost of the whole plant is known, it is then practicable to determine for that

engine the point of cut-off which will give the most power for the money already and actually expended.

Assuming, for instance, the principle that the power divided by its cost should be a maximum, the same mathematical expression

$$y = \frac{p_0 V_2}{h.W + K.A}$$

is merely restricted to an apparatus of which the cost is known.

Taking this view of the problem the absurdity of including in any manner in the variable term of the denominator ($h.W$) the interest on the cost of the boiler, firemen's wages, insurance, depreciation of value from use, repairs, etc., is evident at once; because none of these items vary with the quantity of steam used.

Moreover, it is not necessary to estimate the interest on the cost of the engine K by the square foot of piston, but the formula, admitting for the sake of argument, its validity, should be

$$y = \frac{p_0 V_2}{h.W + K}$$

in which $h.W$ includes only those items of cost which vary with the quantity of steam used, and in which K includes all the constant hourly expenditures of the plant, including boiler and engine. We should thus have to include in h only the cost of making one pound of steam per hour estimated from the price of coal, while K would necessarily embrace the following items.

1. Hourly interest on cost of boiler.
2. " " " engine.
3. " " " chimney.
4. " " " boiler room and engine room.
5. Wages of Engineer and fireman per hour.
6. Insurance per hour.
7. Taxes per hour.
8. A portion of the wages of general foreman and manager per hour.
9. Estimated repairs per hour.
10. Sinking fund for redemption of cost of boiler and engine, estimated to last (blank) years.

Everything, in fact, must be included which can reasonably be charged to the cost of the power, as distinguished from expenditures for utilization of power and other expenses connected with it.

In this mathematical formula for which it has recently been claimed that it furnishes "*the only correct solution which has ever been presented*" and that it is of "*immediate practical use*," we find all of these quantities.

Let us see how they are to be determined numerically:

Interest—Who shall establish the rate?

Cost of engine and boiler—What shall it include?

Boiler and engine room and setting—How shall the cost be separated from that of the rest of the plant, in a manufacturing establishment, or in a steamship from other parts of the structure?

Wages of engineers and firemen—What shall be done if these wages should happen to change from time to time?

Insurance—When a whole establishment is insured what part shall be charged to power?

Salaries of general foreman and manager—What part shall be charged to power?

Repairs—What amount shall be *estimated?*

Sinking Fund—How *estimated?*

Who can estimate the life of a boiler or an engine?

All or nearly all of the above quantities can be assumed only by mere guesswork—there is not a shadow of a guide or a rule for most of them, not even the results of experience which so often aid in the solution of practical problems.

If the quantities in the formula are arrived at by mere guess, and without experience to guide the person who guesses, of what value are the results?

A good deal has been said in this connection about the "business man's cut-off" as distinguished from the scientific man's cut-off. This wretched process is like that of finding the correct time, so admirably described by John Phœnix in his burlesque exploring expedition from San Francisco to the "Mission," one of its suburbs. The party, after attempting for a whole night to determine the true time by observations of the stars with a transit, which could not be properly adjusted, concluded that it would be just as well to step into a corner grocery and get the time from the grocer's clock.

There is one other important consideration which should not be lost sight of in applying this method to a given plant, viz., that not until all these questions of cost have been successively guessed at and thus established, and not until after the boiler and engine have been erected,

ready for running, will the manufacturer or the steamship owner know what power he has at his disposal. The power developed at the "business man's" economical point of cut-off depends on these items of cost, and he must accept what his guesswork has given him.

Possibly the power thus available will not run his works or his ship, and he may find that in attempting this mode of economy he is a greater loser in the end for want of sufficient power or from having too much power. The moment dollars and cents enter into a problem it ceases to be a mechanical, and becomes a financial one; and in such problems there must always be two sides to the account.

A horse-power as power has no standard or intrinsic value; its value depends entirely npon its serving fully and precisely the objects for which it is employed.

A definite amount of power just sufficient for performing a given work has a certain value, where one-half or indeed any less power might be of no value, and more power might involve loss.

Steam-power is like a manufactured article, and the question of preventing waste in the manufacture, by high grades of expansion and costly engines, is one in which all the conditions and circumstances of the use of the power must be considered. It cannot be narrowed down to a mere ratio between the cost of the engine and the cost of fuel as is claimed in the new method.

The attempt to apply this new method to marine engines in public vessels, where no questions of interest and of profit and loss can enter, is not the least of the absurdities that have marked the discussion of the subject.

The introduction of the sinking fund idea as a part of the cost involves another absurdity, because the operation of a sinking fund is to reduce the principal of the debt, and the value of the quantity K, in the formula assumed as constant, is not a constant under this assumption, but a variable quantity, practically a vanishing quantity. Thus the validity of the mathematical discussion is destroyed, even if there were no other elements of unsoundness in the process. It seems to me unfortunate that crude ideas on this subject should have been put forth as the results of exact scientific investigation, and a theorem practically abandoned by its author, invoked to persuade business men that our most eminent and successful engineers of the present day have been practically ignorant of correct principles regarding the economical use of steam.

Nothing tends more to bring science into disrepute with those engaged in industrial pursuits than the hasty announcement in the name of science of conclusions or results, as truths, which are merely personal and unverified speculations, or false deductions from assumed and unproved premises.

THE SPECIFIC HEAT OF PLATINUM, AND THE USE OF THIS METAL IN THE PYROMETER.

By J. C. Hoadley.

In a paper which I had the honor to present to the American Society of Mechanical Engineers at the meeting held at Hartford in May, 1881, I gave, as the best estimate of the mean specific heat of platinum which I was able to form—based on the data to be found in Clarke's "Constants of Nature"—0·0333, equal to one-thirtieth of the specific heat of water under standard conditions; and apparently uniform, or nearly so, at all temperatures ordinarily attainable. At the same time I stated that a careful study of the original memoirs might disclose such reasons for assigning greater weight to the results obtained by some experimeters than to the varying results obtained by others, as to lead to a probable mean result much more trustworthy than that of my first crude approximation.

Such a study of the original memoirs, and a careful discussion of the several experiments therein described, for which I had neither the requisite facilities nor the necessary leisure, was made during his summer vacation by Mr. Silas W. Holman, Instructor in Physics at the Massachusetts Institute of Technology, who generously placed at my disposal the interesting and valuable fruits of his labors.

Mr. Holman first clearly points out the distinction between the terms "true specific heat" and "mean specific heat." The *true* specific heat of any substance at $t°$, is the amount of heat, expressed in heat units, required to raise the unit weight of the substance from any temtemperature $t°$ to $t° + 1°$, or more properly from $t°$ to $t° + dt$, whence we may write the true specific heat at $t° = \frac{dh}{dt}$ = first differential coefficient of the heat with regard to the temperature (of course

not passing through change of state, as from solid to liquid, or from liquid to gaseous).

On the other hand, the *mean* specific heat from 0° to $t°$ is the amount of heat, expressed in heat units, required to raise the unit of weight from 0° to $t°$, divided by the number of degrees of this temperature $t°$, 0° in this case being 0°C. For Fahrenheit degrees the equivalent expression is the amount of heat required to raise the unit weight from 32° to $t°$, divided by the number of degrees embraced between 32° and $t°$.

Confining ourselves, for the sake of simplicity, to centigrade degrees, for the present, let h_t, h_{t_1}, etc., = number of heat units required to raise unit weight from 0° to $t°$, $t_1°$, etc., respectively. Then let $\frac{h_t}{t}$, $\frac{h_{t_1}}{t_1}$, etc., = mean specific heat from 0° to $t°$, $t_1°$, etc., respectively. Also, $h_{t_1} - h_t$ = number of heat units required from $t°$ to $t_1°$. Then $\frac{h_{t_1} - h_t}{t_1 - t}$ = m. sp. ht. from $t°$ to $t_1°$. Now $h_t = t(a + bt + ct \ldots .)$,

and $h_{t_1} = t(a + b_{t_1} + ct_1^2 + \ldots .)$.

$\therefore h_{t_1} - h_t = a(t_1 - t) + b(t_1^2 - t^2) + c(t_1^3 - t^3) + \ldots$

$\therefore \frac{h_{t_1} - h_t}{t_1 - t} = a + b(t_1 - t) + c(t_1^2 - 2tt_1 + t^2) + d(\ldots . \text{etc.})$

which, at the limit when t_1 approaches t, becomes the *true* specific heat at $t° = \frac{dh}{dt} = a + 2bt + 3ct^2 + 4dt^3 + \ldots$, while the *mean* specific heat from 0° to $t° = \frac{h_t}{t} = a + bt + ct^2 + dt^3 + \ldots .$ etc.

The neglect of this obvious distinction, and the confusion of *mean* with *true* specific heat, vitiated my work. The location of points on my diagram, representing mean specific heat determinations at points midway between the two extremes for which the determinations were made, was erroneous and confusing. For instance, the determination 0·03818, for the mean specific heat 0° to 1200°C., should have been located at 1200° on my diagram, instead of at 600°, as I located it.

Mr. Holman also introduces Violle's results for the specific heat of platinum, which he considers the best results by far which we possess.

In discussing the results Mr. Holman remarks, as I had already

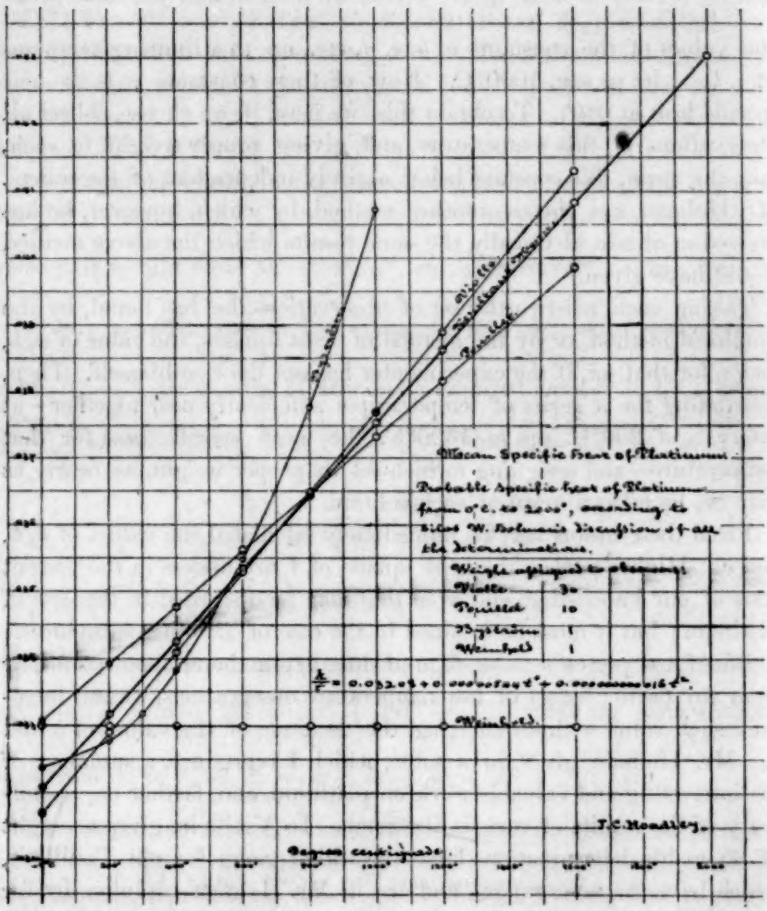
done, that every observer has found for platinum an increase of specific heat with increase of temperature, and that the *rates* of increase found by the various observers are not very diverse. In the expression $\frac{h_t}{t} = a + bt + ct^2 + dt^3 + \text{etc.}$, we wish to find the most probable values of the constants a, b, c, d, etc., up to a limiting temperature, $t =$, let us say, 1000°C. Now, of these constants a is the *true* specific heat at 0°C. To obtain this, we may, if we choose, collect all observations at this temperature, and, giving proper weight to each, take the mean, this constant being entirely independent of the others. Mr. Holman has chosen another method, by which, however, he has arrived at almost identically the same results which the above method would have given.

Taking each trustworthy set of observations, he has found, by the graphical method, or by the method of least squares, the value of a, b, and c, for that set, if the experimenter has not done so himself. Then, calculating for a series of temperatures sufficiently near together—at intervals of 200°C. up to 1600°C., the mean specific heat for that temperature—and assigning to each set its proper weight, as nearly as may be, he takes a mean of each column.

From these means may be immediately calculated the values of a, b, and c. Higher powers than the square of t are useless in the present state of our knowledge, and even that may be discarded in the case of platinum; but it must be retained in the case of all other substances.

But if we prefer a value of a deduced from more observations, or from any particular set of low temperature observations, we can introduce such value without affecting the accuracy of the values of b and c. Mr. Holman gives in a table, which I reproduce, a summary of his interesting and valuable work on platinum, and, farther on, a summary of the results of various observers. To Violle he gives a weight of 30, as his determinations have the widest range (except Pouillet's, which have the same range), and are, in Mr. Holman's opinion, by far the most thorough, careful and accurate, and Violle being a skillful observer. To Pouillet's determinations Mr. Holman assigns a weight of 10, as having the same range as Violle's, but without the advantage of all the facilities for accurate work possessed by the latter. Byström's results are apparently pretty good, but extend only to 300°C., and are therefore entitled to but little weight when extrapolated to 1000°C.

Weinhold's results have not equal concordance among themselves, nor do they appear to have been made with the same degree of care and skill as even Pouillet's.



The above $\frac{k}{t} = 0{\cdot}03208 +$ etc., should read $k_t = 0{\cdot}03208 +$ etc.

To Byström's and Weinhold's determinations, which he considers of little value, Mr. Holman assigns a weight of one each.

In all cases it will be noted that the temperatures are upon the air thermometer.

Mean Specific Heat of Platinum from 0° to t° C.

Observer.	Wt.	$t° = 0°$	200°	400°	600°	800°	1000°	1200°	1600°
Violle.....	30	·0317	·0329	·0341	·0353	·0365	·0377	·0389	·0413
Pouillet.....	10	·03307	·03392	·03477	·03562	·03649	03732	·03817	·03987
Byström.....	1	·03239	·03278	·03381	·03547	·03778	·04073	·04431	·05341
Weinhold.....	1	·0330	·0330	·0330	·0330	·0330	·0330	·0330	·0330
Means.....		·03208	·03315	·03423	·03533	·03758	·03645	·03871	·04105

From the above means Mr. Holman deduces approximations which he considers sufficiently exact as the mean specific heat from 0° to $t°$, $k_t = 0{\cdot}03208 + 0{\cdot}00000544\,t° + 0{\cdot}000000000016\,t^2$, or, if ct^2 be dropped, $k_t = 0{\cdot}03208 + 0{\cdot}00000547\,t$, for platinum.

It will be observed that when the third term, ct^2, is omitted, Mr. Holman's curve, when represented graphically, becomes a straight line, and that the eighth decimal in the constant b becomes 7 instead of 4.

Mr. Holman deduces, in a similar manner, but with less exactness, on account of the paucity of material, the probable mean specific heat of iron from 0°C. to 300°, 600° and 1000°C., as exhibited in the subjoined table:

Mean Specific Heat of Iron from 0° to t° C.

Observer.	Wt.	$t = 0°$C.	300°	600°	1000°
Weinhold.....	5	·10591	·13150	·16907	.2378
Bède.....	3	·1053	·1266	·1479	·1763
Byström.....	2	·11164	·11703	·13100	·1629
Means.....		·10687	·12714	·15510	·2044

From these means is deduced the following equation for the mean specific heat of iron:

$$k_t = 0{\cdot}10687 + 0{\cdot}0000547\,t + 0{\cdot}0000000428t^2$$

In this expression, the third term, ct^2, cannot be neglected; the line

is distinctly a curve. These constants are in all cases for centigrade degrees, and must be multiplied by $\frac{5}{9}$ to reduce them for Fahrenheit degrees. Performing this multiplication, the expressions become, in Fahrenheit degrees:

For the mean specific heat of platinum, from 32° to t°F.:

$$k_t = 0{\cdot}03208 + 0{\cdot}0000030\dot{2}\dot{2}(t - 32) + 0{\cdot}000000000009\,(t-32)^2$$

or, omitting the last term, as we may safely do, for platinum:

$$k_t = 0{\cdot}03208 + 0{\cdot}00000304(t° - 32)$$

For the mean specific heat of iron, from 32° to t°F:

$$k_t = 0{\cdot}10687 + 0{\cdot}0000304(t - 32) + 0{\cdot}0000000238\,(t-32)^2$$

For pyrometric purposes, iron and all other metals save platinum may be left out of consideration. For platinum, my assumption of $\cdot0\dot{3}\dot{3}\dot{3} = \frac{1}{30}$, as the uniform specific heat at all ordinary temperatures, is found to be correct only at a certain temperature, namely, 446·15° Fahr., equal to 230·108°C. At all temperatures below this my assumption, $0{\cdot}3\dot{3}\dot{3}$, is too high; at all higher temperatures it is too low.

The rate at which the mean specific heat changes is, per degree F., 0·00000304 deg.

For the 32°F. between 0°F. and 0°C., the difference in m. sp. h. is $32 \times 0{\cdot}00000304 = 0{\cdot}00009728$, and this difference subtracted from the mean sp. h. of Pt. at 0°C. will give the m. sp. h. of Pt. at 0°F. thus: $0{\cdot}03208 - 0{\cdot}00003728 = 0{\cdot}03198272$.

Of course we may substitute this value of the first term, a, this number, ·031983 (specific heat of platinum at 0°F.), for the number in the table, 0·03208 (sp. ht. of Pt. at 32°F.), when $t°$ will be the temperature F. from 0°F., and the 32° must not be subtracted from t.

The assumption, $0{\cdot}0\dot{3}\dot{3}\dot{3}$, for the first approximation in proportioning the pyrometer, is a very convenient one. Quite correct for the temperature indicated by 446·195°F. = 230·108°C., which is about the upper limit of accurate indication by the mercurial thermometer, the corrections to be applied from this point upward are all in the same direction, all *minus*. For example, 1050·4° observed, = 1000° corrected; 2022·4° observed, = 1800° corrected.

The subjoined table has been computed for the Fahrenheit scale and zero, by the use of the formula

$$k_t = 0{\cdot}031983 + 0{\cdot}0000030\dot{2}\dot{2}\,t + 0{\cdot}000000000009\,t^2$$

Temperatures, in deg. Fahr., corresponding with specific heat in column 2.	Mean sp. ht. of platinum, computed for each 100 deg. Fahrenheit.	Differences of sp. ht. per each 100° Fahr.	Ratio of computed to assumed sp. ht., viz., $\frac{1}{30}$ water = 0·033333.	Differences of ratios for each 100° Fahr.	Observed temperatures by pyrometer at assumed ratio: w. to pt. ball 100 to 1.	Differences of observed temperatures per 100° Fahr.
1	2	3	4	5	6	7
0	·031983		·95950		—1·3	
		303		907	30·8	98·2
32	·032090		·96240			
		302		907	96·9	98·6
100	·032286		·96857			
		302			195·5	
200	·032588		·97764			
		303		908	207·5	100·5
212	·032624		·97783			
		302		908	296	102·3
300	·032891		·98672			
					398·3	
400	·033193		·99580			
		303		909	446·2	104·1
446·195	·033333		1·00000			
		304		910	502·1	106
500	·033496		1·00489			
		303		910	608·4	107·8
600	·033800		1·01399			
		303		910	716·2	109·6
700	·034103		1·02309			
		304		911	825·8	111·4
800	·034406		1·03219			
		304		912	937·2	113·2
900	·034710		1·04130			
		304		912	1050·4	115·1
1000	·035014		1·05042			
		304		913	1165·5	116·9
1100	·035318		1·05954			
		305		913	1282·4	118·7
1200	·035622		1·06867			
		304		914	1401·1	120·6
1300	·035927		1·07780			
		305		914	1521·7	122·4
1400	·036231		1·08694			
		305		915	1644·1	124·3
1500	·036536		1·09608			
		305		915	1768·4	126·1
1600	·036841		1·10523			
		305		916	1894·5	127·8
1700	·037146		1·11438			
		306		917	2022·4	129·7
1800	·037451		1·12354			

Temperatures, in deg. Fahr., corresponding with specific heat in column 2.	Mean sp. ht. of platinum, computed for each 100 deg. Fahrenheit.	Differences of sp. ht. per each 100° Fahr.	Ratio of computed to assumed sp. ht., viz., ⅓ water = 0·033333.	Differences of ratios for each 100° Fahr.	Observed temperatures by pyrometer at assumed ratio: w. to pt. ball 100 to 1.	Differences of observed temperatures per 100° Fahr.
1	2	3	4	5	6	7
1900	·037757		1·13271		2152·1	
		306		917		131·7
2000	·038063		1·14188		2283·8	
		305		917		133·4
2100	·038368		1·15105		2417·2	
		306		918		135·3
2200	·038674		1·16023		2552·5	
		307		919		137·2
2300	·038981		1·16942		2689·7	
		306		919		139·0
2400	·039287		1·17861		2828·7	
		307		920		140·8
2500	·039594		1·18781		2969·5	
		306		920		142·7
2600	·039900		1·19701		3112·2	
		307		921		144·6
2700	·040207		1·20622		3256·8	
		307		921		146·4
2800	·040514		1·21543		3403·2	
		308		922		148·3
2900	·040822		1·22465		3551·5	
		307		923		150·1
3000	·041129		1·23388		3701·6	
		308		923		152·0
3100	·041437		1·24311		3853·6	
		308		923		153·9
3200	·041745		1·25234		4007·5	
		308		924		155·7
3300	·042053		1·26158		4163·2	
		308		925		157·6
3400	·042361		1.27083		4320·8	
		308		925		159·5
3500	·042669		1·28008		4480·3	
		309		926		161·3
3600	·042978		1·28934		4641·6	
		309		926		163·2
3700	·043287		1·29860		4804·8	
		309		927		165·1
3800	·043596		1·30787		4969·9	
		309		927		166·9
3900	·043905		1·31714		5136·8	
		309		928		168·8
4000	·044214		1·22642		5305·6	

University of Michigan

The corrections *below* 446·195° are *plus.*

The lines 32° and 212° are inserted for convenience in testing the pyrometer for verification. At 32° true temperature the indicated temperature is 30·8, a correction of +1·2°. At 212°, or the boiling point, the indicated temperature is 207·5, a correction of +4·5°. In my pyrometer the water and so much of the metal as shares its temperatures being together equal to 2 pounds of water, and the platinum ball being 0·6 lb., and the assumed sp. ht. $\frac{1}{30}$ that of cold water, the assumed ratio is 100 to 1; and with good thermometers having about 0·8 in. to 1°— graduated to 0·1°, on which $\frac{1}{40}$ or even $\frac{1}{50}$ of a degree can be accurately read, the greatest error need not exceed 6°. By skillful manipulation error is nearly eliminated.

It will be observed that the table is carried up to 4000°F., the reputed melting point of platinum.

Since the highest temperature at which the sp. ht. of platinum has been determined is 1200°C. = 2182°F., all the numbers in the table above 2200° must be received with a certain degree of gradually increasing reserve; and the analogy of other metals leads us to suppose that between 3000° and 4000° the specific heat may rise more rapidly than the formula indicates. There can be no great error up to 3000°—and between that limit and 4000° it can only be said that the figures here given are the best attainable, and if of little practical use may sometimes be better than none.

Action of Colored Lights on Vegetables.—M. G. Mernet gives the following results of observations: 1. The luminous intensity necessary for white light to decompose carbonic acid is a little less than that which is required for the most active colored rays. 2. Under a clear sky and burning sun the action begins and ends instantaneously in light and shade. 3. For a temperature of 15° to 25° (59° to 77° F.), but under a cloudy sky or a luminous mist the colored rays are inactive. 4. All the colored rays are efficacious, but in different degrees. 5. The yellow rays always have the greatest activity, the red rays the least. 6. Under the influence of some unknown cosmic curve the proportional influence of the orange and red rays, and still more of the violet, indigo and blue rays, is variable. 7. Partial results of experiments indicate the following order of activity: yellow, orange, red, violet, indigo, blue, green. 8. For equivalent durations of illumination the work of the colored rays is sensibly equivalent to the work of the white.—*Le Genie Civil,* ii, 305.

C.

BELL CHIMES IN PHILADELPHIA AND OTHER PLACES.

By JOHN W. NYSTROM.

There are four peals of bells in Philadelphia, namely, at the Churches of *Christ, St. Peter, St. Stephen* and *St. Mark;* of which only one peal is cast in this country and the other three in England.

PEAL OF CHRIST CHURCH.

The oldest peal in Philadelphia is that of Christ Church, Second street above Market, consisting of eight bells cast in the year 1754, by Lester & Pack, of the foundry which now bears the name of Mears & Stainbank, 267 Whitechapel, London.

The whole peal weighs 9,000 pounds, and cost £560 in London (about 30 cents per pound).

Dimensions of the Bells at Christ Church.

Bells and Keynote.	Actual Vibrations	Diameter. Inches.	Soundbow. Inches.	Soundbow. Strokes.	Weight. Pounds.	Timbre.
Tenor F	352	$46\frac{3}{8}$	$3\frac{1}{4}$	0·701	2040	566
2d G	394	40	$2\frac{7}{8}$	0·718	1400	535
3d A	431	39	$2\frac{78}{100}$	0·717	1295	570
4th B♭	470	37	$2\frac{11}{16}$	0·727	1116	536
5th C	505	34	$2\frac{5}{8}$	0·772	921	564
6th D	593	32	$2\frac{1}{2}$	0·780	777	590
7th E	660	$29\frac{1}{2}$	$2\frac{1}{2}$	0·848	660	562
Treble F	702	$29\frac{3}{4}$	$2\frac{3}{4}$	0·924	735	550

Total, 8944 pounds.

The tenor broke in the year 1835, and was recast in the same foundry but of a smaller size, so that the old clapper was too long and,

when tolled for the first time, a big piece was broken off the lip of the new tenor, which is now rung in that condition and weighs 2,040 pounds.

The fifth bell, C, was broken in the year 1865, and recast in the same foundry, but became lower in tone or nearer B than C.

The pitch of tone of the bells agrees nearly with that established by the Stuttgart Congress in the year 1834, or 80 years after the bells were cast.

The bells are hung to swing for change ringing, which was at the height of excitement at the time the peal was cast, but that style of bell-ringing has since gradually declined until now the chimes are generally rung by swinging the clapper with a rope attached thereto, although the bells may be hung for swinging.

Change Ringing.

Change ringing is more of a curiosity in mechanic arts than art of music.

A band of English bell-ringers visited this country in the year 1850 and rang the peal of Christ Church on June 9th, under the direction of Mr. Henry W. Haley, who managed to ring 5,040 changes in three hours and fifteen minutes, with consummate skill, and being the first or probably the only change ringing in the United States of America up to this time, was duly appreciated by many attentive listeners.

Celebrated bell-ringers amuse themselves with the rule of permutation, to find how many changes can be rung on a given number of bells, and what time it takes to ring each number. The bells to ring about 96 strokes per minute in continued succession, without melody.

The product of the number of bells and number of changes gives the total number of strokes. (See table, next page.)

The writer has lately constructed a peal of four bells, and arranged for it eight different pieces of music, selected from operas and various songs, which have been played on the peal. By such arrangement, millions of changes can be rung on four bells, whilst by the ordinary change ringing only 24 unmelodic changes can be made.

The writer has rung the well-known song "Far over the Stars is Rest" and other songs upon the peals at St. Mark's and St. Stephen's Churches.

TABLE FOR CHANGE RINGING.

Number of bells.	Number of changes that can be rung.	Time required to ring the changes.
2	2	Two seconds.
3	6	Twelve seconds.
4	24	One minute.
5	120	Five minutes.
6	720	Half an hour.
7	5,040	Three hours and a half.
8	40,320	One day and four hours.
9	362,880	Ten days and twelve hours.
10	3,628,800	Fifteen weeks.
11	39,916,800	3 years and 60 days.
12	479,001,600	37 years and 355 days.
13	6,228,020,800	500 years.
14	87,178,291,200	7,000 years.

PEAL OF ST. PETER'S CHURCH.

The peal of eight bells at *St. Peter*, corner of Third and Pine streets, was presented to that Church in the year 1842, by Benjamin Wilcocks, a member of the congregation. The bells were cast by Mears, 267 Whitechapel, London, and brought to Philadelphia, free of charge, by Capt. Henry Miercken, also a member of the parish.

The pitch of tone agrees nearly with the English scientific pitch, making C = 512 vibrations per second, which is one quarter of a note lower than the Stuttgart pitch.

Dimensions of the Bells at St. Peter's.

Approximate Key-note.	Actual Vibrations	Diameter.		Soundbow.		Weight.	Timbre.
		Cast.	Toned.	Inches.	Stroke.	Pounds.	
Tenor F	343	44½	44½	3 1/16	0·689	1733	528
2d G	384	39¾	39¾	2¾	0·694	1212	533
3d A	424	37	37	2½	0·668	1073	574
4th B ♭	454	35½	35½	2½	0·705	983	558
5th B	484	33¼	32	2⅜	0·729	774	528
6th C	512	31	31	2 7/16	0·787	731	519
7th C♯	542	30½	29¼	2 7/16	0·834	638	498
Treble D	566	28½	28½	2⅜	0·833	608	536

Total, 7,752 pounds.

The bells are hung to swing for change ringing, but have not been so used, as far as the writer knows, but the clappers are swung by ropes for chime ringing.

The tenor is chipped here and there, inside the soundbow, for lowering the note.

The second bell is not chipped nor turned.

The third bell is turned off half an inch on the lip, for raising the note.

The fourth bell is very much chipped all round, inside the soundbow, for lowering the note.

The fifth bell is turned off five-eighths of an inch on the lip, for raising the note.

The sixth bell is not chipped nor turned.

The seventh bell is turned off one-half of an inch on the lip.

The treble is very much chipped all round, inside the soundbow, for lowering the note.

Peal at St. Mark's Church.

The peal of eight bells at St. Mark's Church, Locust street, between Sixteenth and Seventeenth streets, was cast by Mears & Stainbank, London. The four largest were cast in the year 1876 and the four smallest in 1878.

The cost of the first four bells, including a new floor in the tower and frames for the entire peal, was $4,980 05, in 1876.

The four smaller bells, . 1,977 83, in 1878.

Total, . . $6,966 88.

This includes freight from London and hanging of the eight bells.

Dimensions of the Bells at St. Mark's Church.

Approximate Key-note.	Actual Vibrations.	Diameter.		Soundbow.		Weight.	Timbre.
		Cast.	Toned.	Inches.	Stroke.	Pounds	
Tenor F	352	47	46⅛	3 1/16	0·643	2006	618
2d G	396	42⅜	41⅛	2 11/16	0·634	1407	634
3d A	442	39	38¾	2⅝	0·681	1167	614
4th B♭	469	37	36⅛	2½	0·676	983	618
5th C	528	34	33¼	2½	0·735	867	586
6th D	593	32¼	32	2½	0·775	788	598
7th E	664	30	29¾	2 7/16	0·814	646	593
Treble F	704	29	27⅞	2 6/16	0·842	623	579

Total, 8,487 pounds.

The pitch of tone of the bells at St. Mark's Church agrees very nearly with the Stuttgart standard pitch, which is one quarter of a note above the English scientific pitch.

The bells are hung to swing for change ringing, but have never been so used, for the reason that there are no such bell-ringers in Philadelphia, nor is the tower in which the bells are hung strong enough

for change ringing, and they are therefore chimed by hammers striking the outside of the soundbows.

Peal at St. Stephen's Church.

The peal of nine bells at St. Stephen's was presented to that Church by Mrs. Eliza Howard Burd, September 19, 1853. Messrs. Jones & Hitchcock, of Troy, N. Y., who were the only bidders, secured the contract for these bells at the rate of 32 cents per pound. The peal was completed and rung in December, 1853. Only the tenor is hung to swing, the other bells are hung stationary and their clappers swung by ropes for ringing. The tenor is also rung by swinging the clapper.

Dimensions of the Bells at St. Stephen's Church.

Intended Keynotes.	Actual Keynotes. Fund'tal	Partials.		Actual Vibrations.	Diamet'r Inches.	Soundbow. Inches	Strokes.	Weight Pounds.	Timbre.
Tenor D	D	F·6	B·1	288	$52\frac{7}{8}$	$3\frac{1}{4}$	0·615	2838	590
2d E	E	G·6	C·9	332	47	3	0·638	2112	584
3d F♯	F·8	A·2	C	358	$42\frac{1}{4}$	$2\frac{11}{16}$	0·633	1570	570
4th G	G·1	A♯·6	C·1	386	$40\frac{3}{4}$	$2\frac{5}{8}$	0·645	1430	581
5th A	A	G	C·3	432	$39\frac{5}{16}$	$2\frac{3}{4}$	0·700	1234	569
6th B	A♯·4	C♯·9		465	$35\frac{3}{4}$	$2\frac{11}{16}$	0·754	1019	525
7th C♯	C·1	E		511	$34\frac{9}{16}$	$2\frac{1}{2}$	0·724	912	582
Treble D	C♯·9	F	E	573	$33\frac{7}{16}$	$2\frac{9}{16}$	0·767	863	597
Extra C	B·1	D·7	A♯	483	$33\frac{3}{8}$	$2\frac{3}{8}$	0·714	820	539

Total, 12,798 lbs.

With the kind assistance of the organist of the church, Mr. D. D. Wood, I was enabled to get the upper partials of each bell very correctly in this peal. The numbers in the columns *Fundamental* and *Partials* mean decimals of half a note; for instance, F·8 means that

the note is eight-tenths of half a note above F, which makes it nearly F♯.

Price of the nine bells, . . .	$4,095 36
Charge for hanging, ...	275 00
Total cost, . . .	$4,370 36

There is no sign of the bells having been chipped or turned for toning; but, judging from the timbre of some of the bells, it is presumed that they have been toned by the process of annealing or tempering.

The pitch of the peal is the same as the English scientific pitch, which is nearly half a note lower than Steinway's standard pitch used in this country as concert pitch, particularly by Thomas.

The peal is intended to be harmonically intonated, and to ring in two different keys, namely, in D and G. For the actual intonation it is best suited for the key of G, but the bell intended for C♯ should then be used as C.

The St. Stephen's Church has two towers, one north and one south of the main entrance on Tenth street. The peal is hung in the south tower, and in the north tower is an old but very good bell, cast for the Church in the year 1823, by John Willbanks, who then carried on bell-founding in Shoemaker street below Eighth, in this city.

The well-known bell-founder, Mr. Joseph Bernhard, learned the trade with Willbank and started his own foundry in Market street about the year 1845, and moved to 120 North Sixth street in 1852, where he cast many of the best church bells now rung in Philadelphia.

The first bell constructed by the writer for the U. S. Government, in 1855, was cast by Mr. Bernhard.

Peal of the Holy Trinity Church.

The Church of the Holy Trinity, corner of Nineteenth and Walnut streets, has ordered a peal of eighteen bells from Belgium, which is to be rung by electro-magnetism and expected to be in operation before the end of this year.

Great efforts were made to procure the order for this peal and having the bells cast in Philadelphia, but all in vain. Rev. W. N. McVickar, rector of the Holy Trinity Church, went to Europe in the spring of 1880 and visited several bell-foundries, evidently with the intention of selecting the best place for casting his proposed peal. The

peculiar sweetness of the Belgian bells induced Rev. McVickar to recommend them at home, and it was decided to have the chime cast at a foundry of wide reputation near Ghent. The order for the peal was given in December, 1880, and expected to be finished and rung at Christmas, 1881. Joseph E. Temple, Esq., presents the peal to the Holy Trinity Church, and it was at first intended to have twenty-five bells of two octaves chromatic scale, to be rung by electro-magnetism, operated on a key-board, all offered to be made complete in Philadelphia for $10,000, and ready for service at Christmas, 1880.

Centennial Chime.

The Centennial chime of thirteen bells, hung in Machinery Hall, and which rung in the Centennial Exhibition at sunrise on the 10th of May, 1876, was cast by Henry McShane, of Baltimore, at a cost of $10,000. The whole peal weighed about 21,000 pounds, of which the tenor weighed 4,000 and treble 300 pounds.

After the Exhibition was over, Mrs. A T. Stewart, of New York, bought this peal for the Cathedral at Garden City, Long Island, where it was tried to ring the bells with electro-magnetism, but did not succeed.

The tenor is hung to swing, the others are hung stationary and only the clappers swung.

Bell-Foundries.

The writer has visited many large bell-foundries in Europe, and examined all the most important old bells, and has come to the conclusion that the art of bell-founding has had its *ups* and *downs*, that better bells were made a century ago than now (provided the bells do not improve by age), and that bell-founding is now carried on more as a trade than as an art. The writer had an argument with a Russian bell-founder, in Moscow, about the construction of bells, and suggested that the form of the bell, the composition of the metal, and the moulding and casting should be made so and so, which would make the bell of a much better sound.

"Sound!" scouted the bell-founder, who was a man of practical experience.

> "We do not care about the sound,
> We sell the bell by the pound.
> The sound don't weigh anything,
> But is only heard when the bells ring."

The rhyming part of the above is accidental with English orthography, for in the Russian language it was only prose.

To value ringing bells per pound of weight is equivalent to the valuation of oil paintings per square foot of canvas covered. A bell should be valued by quality and volume of its sound, like a painting which is valued by art.

Sir Edmund Beckett says (page 325, book 21,252 Philadelphia Library, or book 509 Franklin Institute Library), "The Mearses, for a good many years, had the monopoly of church-bell-founding, with the usual result of monopolies, for they have turned out some wonderfully bad ones, though their predecessors in the last century and the early part of this made some famous peals."

The largest peal of bells in this country was made by the Mearses a few years ago, and now hang in the tower of St. Mary's Church, Burlington, N. J., which is said by competent judges to be the finest peal they have heard. Its tenor weighs 2,544 pounds.

Mr. Wm. Brown, the celebrated bell-ringer at St. Stephen's Church, says that the peal at Christ Church is the finest in Philadelphia.

For obvious reasons, the writer must abstain from making comments upon or compare merits or demerits of the different peals, but will only give the data from which any one conversant with the subject can form his own conclusion.

Bradford Peal, England.

The largest peal in England was cast by Taylor, in 1873, and hung in the tower of the Bradford town hall. It consists of 13 bells in the key of A, as follows:

The peal is intended to be harmonically intonated and to ring in two different keys, namely, in A and D. There are not sufficient data recorded for determining the *timbre* and other properties of this peal.

The second peal, in size, in England is that in the Cathedral of St. Paul, cast by Taylor in 1878, consisting of 12 bells with tenor 6,944 pounds.

The third in size is at Exeter Cathedral, which peal weighs 29,196, of which the tenor is 7,552 pounds. The Exeter peal was cast in 1676. The recorded data are not sufficient for analyzing the properties of this peal.

Dimensions of the Bradford Peal.

Intended Keynote.	Diameter. Inches.	Weight. Pounds.
Tenor A	77¼	9,744
2d B	67	6,664
3d C♯	59⅜	4,657
4th D	56	4,266
5th E	50	2,720
6th F♯	45⅝	2,114
7th G	43½	1,789
8th G♯	41½	1,563
9th A	39½	1,420
10th B	35½	1,030
11th C♯	33¾	969
12th D	33	907
Treble E	30¾	870

Total, 38,713 pounds.

Timbre.

When the composition of the bell-metal is 31 weights of tin to 100 weights of copper, the timbre of the best bells is generally 580. The more the timbre varies above or below that number, the worse is the bell.

The great bell cast by Taylor for St. Paul's, in 1881, has a timbre of exactly 580.

Worcester Peal, England.

The fourth peal, in size, in England is that at Worcester Cathedral,

consisting of 13 bells cast by Taylor in 1869, of the following dimensions:

Intended Keynote.	Diameter. Inches.	Soundbow. Inches.	Soundbow. Strokes.	Weight. Pounds.	Timbre.
Tenor D♭	63·	4·8	0·78	5,600	563
2d E♭	56·	4·07	0·726	3,944	588
3d F	50·4	3·7	0·734	2,948	587
4th G♭	47·25	3·44	0·729	2,419	587
5th A♭	42·5	3·1	0·729	1,736	585
6th B♭	38·5	3·	0·780	1,344	562
7th C	36·	3·	0·833	1,256	554
8th D♭	35·	2·9	0·829	1,169	573
9th D	34·	2·9	0·854	1,068	573
10th E♭	32·5	2·8	0·863	980	574
11th F	30·5	2·7	0·885	878	580
12th G♭	29·5	2·44	0·830	806	644
Treble A♭	28·	3·	1·070	775	533

Total, 24,923 pounds.

The peal is intended to be harmonically intonated and to play in two keys, namely, D♭ and G♭.

Effect of Bad and Good Bells.

The ringing of a peal of bad bells is a detestable nuisance, which should never be allowed to disturb the peace and solemnity of the Sabbath, and causing, as it does, sufferings to those of sensitive ears

who may unfortunately be within earshot of that noise. They say about the bell-ringers

> "Disturbers of the human race,
> Your bells are always ringing.
> We wish the ropes were round your necks
> And you upon them swinging."

On the other hand, when we hear

> "A chime of good bells,
> How many a tale their music tells,
> Of youth, and home, and that sweet time
> When first we heard their soothing chime."—MOORE.

ERRATUM.—In the article on "Bells," in the preceding number of the JOURNAL, the word *treble* is printed *triple*.

ELECTRIC CLOCKS AND TIME TELEGRAPHS.

By LOUIS H. SPELLIER.

[Abstract of a Paper read at the Stated Meeting of the Franklin Institute, May 17, 1882.]

Two years ago I read a paper before the Institute on the subject of "Electro-magnetic Time Telegraphs," or electric clocks that receive the time telegraphed in certain intervals from a weight or spring clock.

I then stated that "they mainly depend upon the action of one electro-magnet and one armature." The latter is a piece of iron which is attracted by the poles of the electro-magnet, when the telegraphing clock completes the circuit of a galvanic battery connected with it. As soon as the clock breaks the circuit again, the armature is repelled to its former position by a spring or weight. This movement of the armature turns a wheel which drives time-indicating machinery, and is repeated as often as this machinery requires to indicate the time of the clock, which makes or breaks the electric circuit.

Such instruments work very well, if the action of the armature is needed about once every minute, but if repeated every second or two, then its imperfections become apparent. The movement of the armature is sudden and rapid. With a lightning-like velocity the armature moves toward the magnet, and is checked instantaneously in its rapid progress just at a time when nearest to the magnet and most powerfully

attracted. Naturally the wheel, which receives its impulse directly from the armature, moves with the same rapidity and is checked as suddenly. These sudden checks, offered to the armature and wheel, show their damaging results in a short time, and soon impair the correctness of such instruments.

These clocks, as a rule, soon get out of repair, as may be seen by those in use at the Pennsylvania Railroad Depot in this city. Their noise resembles that of a hammer striking forcibly upon an anvil and it is only surprising that they run as long as they do.

To meet the above-mentioned faults of electric clocks is the purpose of the device of my electro-magnetic escapement, of which I exhibited

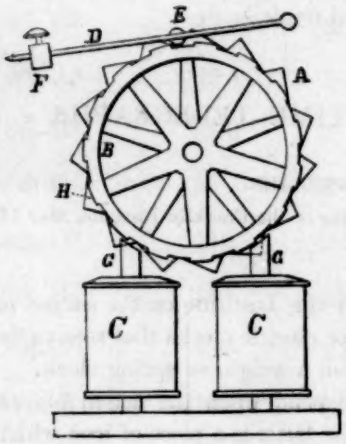


Fig. 1.

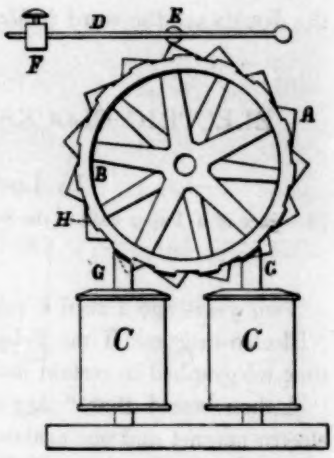


Fig. 2.

here my first model about two years ago, and which is, indeed, the only second system of time telegraphs that is new in its fundamental principle that has been invented in almost half a century.

With the aid of the accompanying cuts, Figs. 1 and 2, which show the principle of my electro-magnetic escapement in its two main positions, I will be able to explain the manner in which I have corrected these evils by the invention of my system. Referring then to Figs. 1 and 2, *G* is the electro-magnet, *B* is an iron wheel that has on its circumference the projections *H*. Those projections are armatures. Fastened to the same axle with this iron wheel is the escape wheel *A*, with the peculiarly shaped cog shown in the drawing. *D* is a lever

with an adjustable weight at *F*, and presses by means of the pulley *E* on its circumference and rests at the bottom of the cog, when the electro-magnet is not charged with magnetism. When in that position, as shown by the drawing to the left, two of the armatures are very near to the poles of the electro-magnet.

At the moment when the electric current passes through the coil *C*, and the poles *G* become magnetized, the two armatures will be attracted and take their position right over the poles of the electro-magnet as shown by the drawing to the right.

The escape wheel *A* fastened to the same axle with *B* has moved with it and lifted up the lever *D*, and has in its movement gone so far as to allow the pulley *E* to glide over the point of the cog and keep its position, shown on the drawing to the right, until the electric circuit is broken again; then the poles *G* become demagnetized, the armatures are no longer attracted, and the wheels *A* and *B* move under the pressure of the pulley until it has reached the bottom of the cog. By this movement the next succeeding two armatures have taken their position shown to the left, again ready to be attracted at the next closing of the electric current. In this manner is produced, by alternately opening and closing the circuit, a step-like movement of *A* and *B*. You will perceive that the object aimed at to avoid violent checks of the armature is completely achieved. Another advantage of no less significance is gained, namely, that it is impossible for the escape-wheel to move without an extra provision, at any given impulse, more than one cog.

Before I show the application of my escapement to time telegraphs I will explain the manner in which I make and break the circuit by means of a weight clock, in order to transmit the time to the electro-magnetic escapement. This current-breaker, Plate I, Fig. 1, I have found to be very effective. *B* is a metal disk fastened to the axle of the escape-wheel of a clock. It has platinum pins vertically upon its face. *C* is another smaller platinum disk fastened to the pin-bearing disk, *b* and *b'* are two springs with platinum terminations. The spring *b* rests on the platinum disk, while *b'* forms the contact with the platinum pins.

When the disk moves with the escape-wheel of the clock it will complete the circuit of the galvanic battery, whenever the spring *b'* comes in contact with one of the pins, and when the spring is removed from the pin, the circuit is broken.

I found this current breaker fully to answer its purpose and to meet

all the requirements. It prevents by means of friction all accumulation of dust and oxidation and keeps the contact surface bright.

The best clocks for making the contact for time telegraphs are undoubtedly those provided with a gravity escapement invented by Edmund Becket. Clocks with gravity escapements allow an increase in the weight of the clock to such an extent as is needed for a secure metallic connection of this contact-breaker without affecting perceptibly the impulse given to the pendulum.

I will now show the construction of my time telegraphs for two different purposes; one kind is intended for different apartments of any building, and the other for public clocks only.

Of the first-mentioned clock I have six in operation here in our lecture-room, and their construction is shown in Figs. 1 and 2, Plate II. This is the clock with a centre or sweeping second-hand, of which I possess but one specimen. The figures show a front and side view of it, and it will at once be recognized that *GC* is the electro-magnet, *A* the escape-wheel, and *B* the iron wheel with its projecting armatures. *D* is the pressing lever with its pulley *E*, and *F* the adjustable weight.

It is unnecessary to explain the action of the escapement again, nor to explain the purpose of every wheel, but I will merely state that *H* is the wheel that carries the hour hand, *M* the minute hand, and *S*, the extended pivot of the escape-wheel axle, is to receive the second-hand.

The electric current acts in these clocks once in every *four* seconds, and if the duration of the current is that of two seconds, the second-hand will execute the movements of a clock provided with a two second-beating pendulum. If, however, the circuit is closed once in four seconds for a time just long enough to allow the attracted armatures to take their proper position over the poles of the magnet, for which a fraction of a second is fully sufficient, it is evident that a great saving of electrical force is gained, and the battery employed will need a less frequent attention. The duration of the current can be easily regulated by adjusting the contact spring *b'* of the current-breaker. If the spring is set more or less deeply into the circle of the contact-pins, a contact of longer or shorter duration between spring and pins will be effected accordingly. The escape-wheel has a diameter of two and three-eighths inches, while that of the armatures has a diameter of two and one-eighth inches. The dial of the clock has a diameter of two feet. It can be made, however, two feet and a half

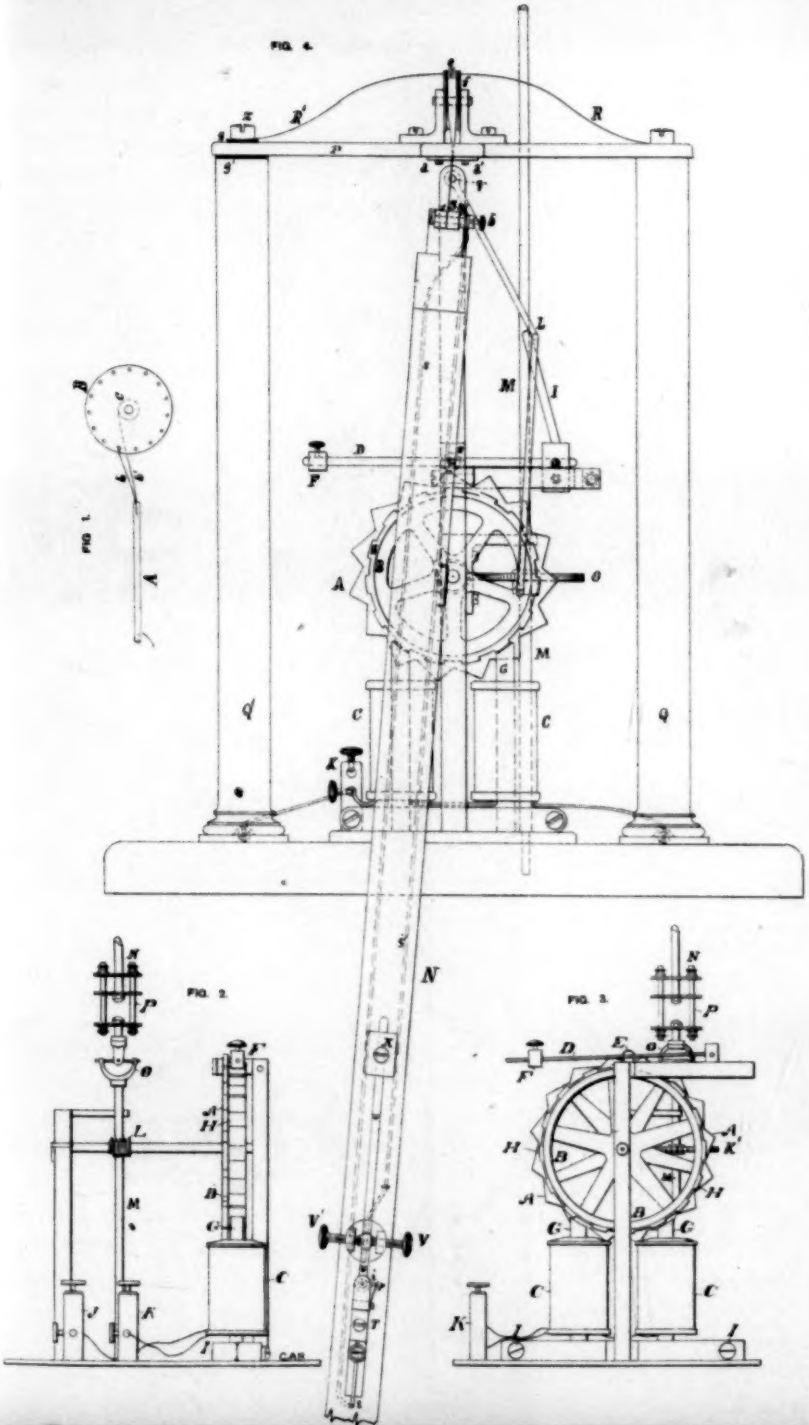


FIG. 4.
FIG. 1.
FIG. 2.
FIG. 3.
CAR

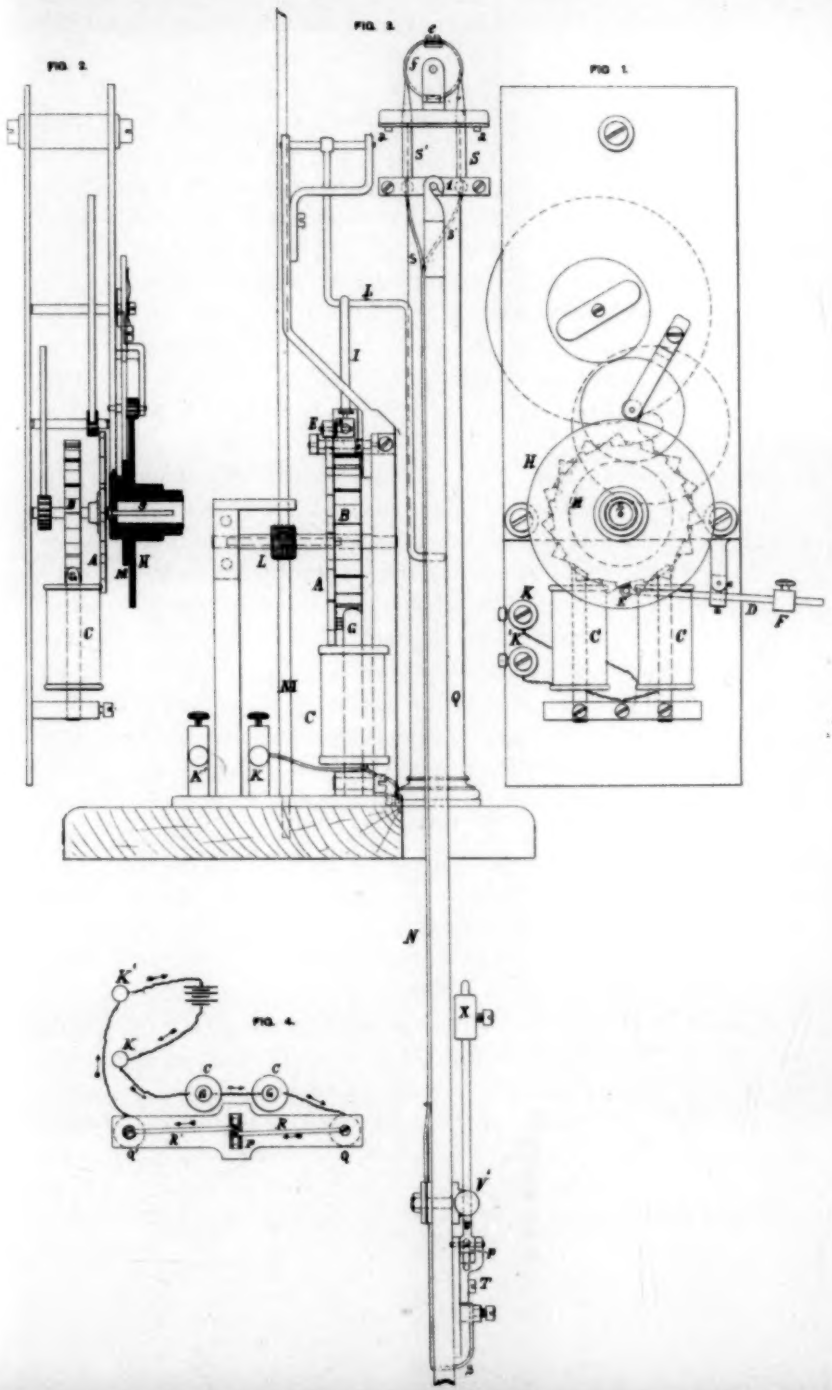


FIG. 2.
FIG. 3.
FIG. 1.
FIG. 4.

without overtaxing the small escapement with more work than it can perform.

I have been running two of these clocks with one callaud. To make it secure, however, one callaud should be used for each clock. The clocks run very easily and lightly. I direct attention on this point to the clock with centre second-hand here in operation. In order to perceive its beat, it is necessary to bring the ear close to it, when a muffled pulsating sound will be perceived. In this respect my time telegraphs are in striking contrast with those of the old system.

While the latter are the most noisy clocks ever made, mine will prove to be the most noiseless of any clocks invented for their size, the pneumatic clocks, perhaps, excepted,—an advantage very desirable in hospitals, where the very tick of a clock in a sick room will annoy the nervous patient.

I have made the escape-wheels of hard rubber or vulcanized fibre, which makes them very light and easily movable.

The fact that second-beating time telegraphs have been of such a self-destructive nature has driven them almost entirely out of use. In some of the principal cities of Europe electrical clocks are quite common, but the mode of moving the hands once in a minute is generally adopted. This is the case, for example, with the very perfectly arranged series of clocks in the city of Geneva, built at the expense of the city government, and constructed by the eminent electrician, Dr. Hipp. There the time is telegraphed every minute to the watch and clock makers of the city from the astronomical observatory.

The necessity, therefore, of moving the hands once in a minute instead of every second (in order to avoid the early destruction of the mechanism) is avoided by the invention of my escapement, since it moves as lightly as the escapement of any weight or spring clock, and I think with its application a successful future is secured for the time telegraph. If time telegraphs are once made a success, then their advantages are too apparent to need much demonstration. Good time-pieces are exceedingly costly. The city of Paris, which adopted the mode of setting ordinary spring or weight clocks throughout the city through the medium of electricity, has paid for the thirteen clocks employed to do that work from $450 to $500 each.

Institutions that desire correct time in every room of their buildings,

may have it wherever it is desired at a comparatively small expense with one good clock and the use of a well-working time telegraph.

But there is still another field open in which a successful time telegraph can be of great service to the public in general; I mean its application to public clocks of any dimensions. "It has become a problem of great perplexity to this day with the most ingenious minds of the horological world to construct clocks which will overcome the effects of wind and storm beating against the exposed clock dials of public clocks, forcing the hands in one or other direction; and here I think it is that the time telegraph has its future. A good and well-regulated clock, kept at a place of no great change of temperature, will show but very little variation in time. If such a clock controls a time telegraph adapted for tower and other public clocks, it will show the time with only such slight variation as will hardly be noticed by the public."

I have constructed time telegraphs for this purpose and I think with full success. Not very long ago one of our daily papers stated that the reason why they had not an electric clock in the tower of the new building of the Pennsylvania Railroad depot was, that they could not get an electro-magnet strong enough to move the hands! There are plenty of electro-magnets strong enough to do it, but they had no electric clocks of such construction as to answer the purpose.

I have here a time telegraph constructed for the purpose of indicating time on public clocks. It is not large enough to fill a good size pocket, and yet almost sufficient to do the very work. They could not find an electro-magnet powerful enough, and yet the electro-magnet of this instrument I have here is rather small. The diameter of its iron core is but five-sixteenths of an inch, and the escape-wheel belonging to it is only three inches and a quarter in diameter. It is only necessary to add one-third to its size in order to make it of sufficient strength to do the work required of the clock in the tower of the Pennsylvania Railroad depot. A time telegraph for public purposes is here in operation and may be examined after the meeting. Its construction is shown in Plate I, Figs. 2 and 3.

The escapement will be readily recognized, and but very few words will be needed to explain its operation. Fig. 2 shows a side and Fig. 3 a front view. The side view will show that escape-wheel *A* and that of the armature are closely fitted together. The axle has a screw at *L* that moves the wheel *K* on the upright standing axle *M* forming

with *K* an endless screw; if we now connect the axle *M* with the shaft *N* leading to the dial works of a clock dial you will readily understand that all that is now necessary is to make and break the electric circuit connected with the time telegraph and the electric battery as often as is needed for the proper movement of the clock hands.

I have now shown the application of my electro-magnetic escapement on time telegraphs, and I will close that subject by reading to you the opinion given in a report of the Committee on Science and the Arts of this Institute, to whom my escapement was referred for examination. On the merits of the escapement the report reads as follows:

"The principal object we think worthy of commendation is the very ingenious escapement which entirely avoids any sudden jar (for there is no impact) and works smoothly and noiselessly and practically with the least possible friction.

"Believing that the time is not far distant when it will be necessary to transmit time from a standard clock to different points in a large city, or in hotels, factories or dwelling houses, there are no means by which it can be done as cheaply, quickly and accurately as by electricity, and there is no device that promises to do it so well, that we have yet seen, as Spellier's Electro-magnetic Time Telegraph. As we think Spellier's invention such a great step in advance that it merits the warm approval and commendation of the Franklin Institute, we recommend that he be awarded the Elliot Cresson Gold Medal;"—and I hope the result of my efforts has vindicated their anticipations.

I now come to a subject of less general interest, but of not less importance, that of real electric clocks, where the moving power of the whole mechanism is electro-magnetism only. I called such clocks in my paper two years ago more of a scientific curiosity than a useful invention; and yet some of the most prominent philosophers and mechanicians have devoted their time and genius to their construction to make them correct time-pieces. The first who constructed such clocks was Bain, about 45 years ago. At present the clocks of Dr. Hipp seem to take the lead, but although he claims great accuracy for them, they seem not to sustain the claim in every instance. One small specimen of his clocks is exhibited in the window of Mr. Thomas Shaw, Ridge avenue, above Ninth street, of our city. In principle I think it to be a step backwards, as it is but a modified and improved clock of the Bain type.

There are three main difficulties in the way of making electric pendulum clocks a success.

They are, first, the variation of the strength of the electric current of galvanic batteries; second, the danger that the current-breaker will not make a sufficiently secure contact for the passage of the electric current, since the contact is made by the pendulum, which has not in all cases sufficient surplus of power to make a secure contact; and, third, the obstruction which the current-breaker offers to the pendulum in its oscillations. Therefore, electric clocks can only be a success when the above-mentioned difficulties are avoided. I think I have met the difficulties successfully by a clock exhibited here to-night, presently to be explained.

I shall first explain the current-breaker of my clock, and to show how far it differs from those employed up to this day I will introduce this explanation by a brief description of the current-breaker now in use at the astronomical observatory in Paris.

There the pendulum of the clock has two side-extending metal arms. Each of these arms is provided with three screws with platinum terminations. Three levers, separately movable, but in metallic connection, corresponding to the screws, will be either in contact with, or removed from the screws as the pendulum moves to and fro. The levers and the arms are inserted into the circuit of a galvanic battery and an opening and closing of the same, corresponding to the oscillations of the pendulum, will be effected. That the pendulum meets with a comparatively great obstruction in its movement by such a current-breaker cannot well be disputed, and yet the contact cannot be formed with a great deal of force to make it as secure as desired, since the levers have to be very light so that they will not obstruct the pendulum too much in its movements.

I now will show how I effect with a new device of a current-breaker a secure and firm contact, and yet at the same time allow the pendulum to follow the course of its oscillations without meeting with any obstruction. Plate I, Fig. 4, shows a front view of my electric clock, and Plate II, Fig. 3, a side view, in which N is the pendulum and T, V and V' its current-breaker. You see an upright standing lever, U, with a weight X on the top. Near its fulcrum are two screws V V', against the one or the other the lever will rest, if the pendulum is out of its vertical position to one side or the other. Two electric wires, s s', coming down the pendulum rod are in metallic connection with

the two suspension-springs $S\,S'$; both springs are fastened together at e' by an insulated substance, and each of these suspension-springs is again connected with its corresponding spring $R\ R'$. Now let the poles of the galvanic battery be connected with the springs $R\ R'$, and set the pendulum oscillating. If the pendulum has its present position, the lever U rests rgainst the screw V, and forms a metallic contact with the screw. The screw is connected with one of the wires coming down the pendulum rod from one of the suspension-springs, and the lever is again connected with the other wire coming from the other suspension-spring, so that the electric current can pass through the contact made by the lever U and the screw V. If the pendulum has its position on the opposite side, the lever will bear against the screw V'. This screw has an insulating substance upon its termination that keeps the circuit broken. Thus, by the movements of the pendulum to and fro the lever U will bear against one or the other screw and make and break the electric circuit. The fall of the lever from one to the other screw is so small that it needs very careful watching to perceive it. The contact formed proves to be secure. It is made with a great deal of force, since it is formed very near the fulcrum of the lever. You will observe that this simple contrivance of my current-breaker removes two of the principal difficulties which electric clocks have to combat with. It now remains to show how I made the impulse given to the pendulum for its movements independent of the strength of the electric current acting upon the electro-magnet of the clock. The springs $R\,R'$ are connected with the electro-magnet and inserted into the circuit of the galvanic battery. You see in the drawing fastened to the axle of the lever D that moves the escape-wheel, an arm I. Against this arm rests the lever L with its fulcrum at q. The extension of this lever touches the pendulum, while resting on the arm I, when the pendulum hangs in its vertical position.

Now if the pendulum is moved to the left, as it is shown in Plate I, the lever of the current-breaker will bear against the screw V, and close the circuit. The armatures nearest to the magnet are attracted, and the lever D that moves the escape-wheel is raised, and with it the arm I is moved, which in turn raises the lever L; there it remains uutil the pendulum bas taken its position to the right. Then the lever of the current-breaker drops against the insulated screw V', and the circuit is broken, then the lever D suddenly drops down, moving the escape-wheel, while the lever L drops against the pendulum and the

pressure of its weight gives the pendulum the impulse for its oscillations. This action of the mechanism is repeated as the pendulum swings to and fro. If we now consider that the lever is always lifted up to the same height, and its weight is not subjected to any changes, the power, acting upon the pendulum to keep up its oscillations, must be the same at every impulse given, without regard to the attracting force of the electro-magnet. It will be seen that this electric clock makes a firm contact for the electric current to pass; and that it does not obstruct the pendulum in the course of its movements, and also that it makes the movements of the pendulum independent of the strength of the galvanic current. This, I think, embraces all the elements necessary for a true time-piece.

Some few words are in place regarding some details of the clock, to make the entire mechanism understood.

Two hard rubber plates, g and g' are essential to insulate the metal plate P from the screw Z and the post Q, to prevent the current from going directly through the plate P from Q to Q', in which case the current would escape the passage through the current-breaker, and the circuit would be continuously closed.

To avoid the passage of the current through the holes in which the pivots of the lever U move, a spring, p, is fastened to the support of the lever, pressing against a platinum pin, i, at the axle of the lever.

The pendulum suspension of this clock is made according to the principle of my suspension as described in the JOURNAL OF THE FRANKLIN INSTITUTE for July, 1880, to which I must refer for its object and detailed construction. Here it is necessary to state that the pulley f, over which the suspension-springs S S' are laid, is of hard rubber, to keep the springs insulated. 1 and 2 are two bars, also of hard rubber, which support the pendulum, and between which the two ends of the suspension-springs are fastened. The plates a and a' are of the same material and are used to hold the suspension-springs in their proper positions.

The clock, shown in the plates, has an escapement of the same dimensions as the time telegraph for public clocks already described, and is otherwise like it in all its details. It is the first one built, and mainly made to establish its principle. I had attached to it four dials, three feet in diameter, with a battery of three callauds. They can, of course, be made of very small dimensions, and will then require but little battery power to keep them going.

The course of the electric current is indicated by the arrows on the ground plan, Fig. 4, seen below the side view in Plate II.

Now, a few words in conclusion, of the utility of the electric clocks, before I close. They will hardly ever come into general use, and always be a costly novelty for those who desire to have them. If we, however, succeed in constructing correct electric time-pieces, they may become of great value in astronomical observations. The astronomer, while making his observations, listens to the beats of his pendulum clock. The beats of an electric clock are louder and more perceptible than weight clocks, and therefore, more desirable, if correct. But that is not all. We know that the density of the atmosphere is subject to constant changes. The resistance of the pendulum, therefore, through the air will vary with its density, and so disturb, although slightly, the regularity of its movements. This can be avoided with electric clocks by closing them in hermetically closed glass cases with greatly rarified air, and, indeed, a great many clocks exhibited at the last Paris Exposition were provided with this precaution. Among others, those of Dr. Hipp were most numerously represented, but since the barometrical error of pendulum clocks is so slight, and the oscillations of the pendulum on Hipp's clocks not only are greatly obstructed by his manner of forming the contact (although admirably ingenious), but still more by the fact that his pendulum works in reversed order (moving the clock train), it is hard to see how the removal of the slight barometrical error will compensate for the faults his clocks are subject to; unless it is taken as a suggestion for a more perfect clock for the future. There is certainly plenty of reasons for the doubtful reception these clocks have received at the hands of some of our prominent philosophers, and of which Dr. Hipp so greatly complains.*

The perfection of electric clocks, however, should receive its full share of attention and encouragement, for the service they may render at astronomical observatories, for reasons already stated. But such work should not be expected from the enterprise of individuals. It properly belongs to the government, which should always furnish the standards for the use of all the people.

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* See *Electrotechnische Zeitschrift*: Berlin, 1881, page 102.

FELDSPAR AS A SOURCE OF POTASH ALUM.*

By JOHN SPILLER.

The aim and object of this Society, as I understand them, will be not only to record the steps of progress made in actual chemical manufacture, but to take account of "wasted ingredients," with a view to their possible economization in the future. It is under this latter head that I beg leave to offer a few suggestions bearing on the manufacture of alum, which have been sufficiently confirmed by laboratory work to prove my case, although I do not pretend to have turned them as yet to practical account.

Starting from feldspar and the large class of rocks in which it is contained, such as granite, gneiss, porphyry, syenite, green-stone, mica-slate, and the basaltic rocks which together constitute a large proportion of the earth's surface, we find a mineral occurring which contains *more potash and alumina* than is present in common alum. Every chemist knows of the methods of decomposing silicates in mineral analysis by attacking them with hydrofluoric acid; but as it was my object to prepare a *sulphate*, and to work as cheaply as possible, I employed a mixture of fluorspar, feldspar, and sulphuric acid. Alum is formed, together with calcium sulphate, and the gaseous fluoride of silicon. The last named gas, passed into water, gives a finely-divided silica, most useful as polishing powder, and hydrofluosilicic acid, for which there is already occasional use in the arts. Comparing now the percentage composition of feldspar and alum, and taking for the former the mean of three analyses, published by Watts, we get for common Feldspar, "orthoclose."

	Alumina.	Potash.
Stolberg (Rammelsberg),	16·98	14·42
Lomnitz (Valentine Rose),	17·50	1·200
Chomounix (Delesse),	19·06	10.52
Mean	17·85	12·31

or together, say over 30 per cent. of ingredients useful in the manufacture of alum, which salt, when crystallized, contains only 10·83 per

*Journal of the Society of Chemical Industry, April, 1882.

cent. of alumina, and 9·91 per cent. of potash, or 26·74 per cent. of total bases. This looks hopeful from a manufacturer's point of view, for, taking the potash as regulating the yield, 100 parts of feldspar should give nearly 124 parts of crystallized alum, and if the relative deficiency of alkali were supplied, then the yield (calculated from alumina) should be as high as 165 per cent.

In my own experiments I have not succeeded in getting more than an *equal weight*, but I have been working under disadvantage with samples of colored feldspar, containing a considerable quantity of iron. From a piece of white granite I have obtained a fair quantity of alum with very much less iron in solution; and to this point I had arrived when my attention was directed to a previous publication of the fundamental fact in the "Bulletin de la Société Chemique de Paris" for June 7, 1872. The particulars are as follows: At the Paris meeting M. Lecoq de Boisbaudran was describing a process for the extraction of cæsium and rubidium from lepidolite. He attacks the mineral with hydrofluoric acid, and separates the rubidium and cæsium by taking advantage of the difference of solubility of the bi-tartrates. Then M. Guignet, in the discussion, says he "thought it might be possible for this extraction to utilize the action of *sulphuric* acid, and separate the alkalies in the state of alums, this proceeding having been used by him to extract the potash from feldspars." The brief terms of this report (three lines only) do not afford much information, or make it clear that M. Guignet ever worked with a mixture of feldspar and fluor-spar, but he evidently aimed at economizing the potash in feldspar, and may have succeeded in so doing.

Reverting now to my own experimental results, two or three points of practical interest may be mentioned.

1. I find it necessary to get rid of the excess of sulphuric acid by thoroughly heating the decomposed mass in a current of air before dissolving, on account of the extraordinary increase of solubility of alum in acid liquors.

2. When granite is attacked by nascent HF, the feldspar and mica disappear long before the admixed quartz, most of the latter remaining the residue.

3. The employment of sheet-lead vessels is not be recommended, for the cost is great and the low fusion point of the metal restricts too much the degree of temperature which it is needful to apply in order to expedite the decomposition.

When the treatment is successfully accomplished there is the large amount of calcium sulphate to be dealt with, left as a bulky residue on treating with water. It struck me, therefore, that it would be more advantageous to use the mineral cryolite ($3NaF,Al_2F_3$), which is so plentiful in Greenland, in place of fluorspar as previously described. This would augment the amount of aluminic sulphate formed at the same time that it supplied the needful fluoride. Here, again, Persoz, Sauerwein, Thomson and others have described the manufacture of crude alumina salts from cryolite *per se*, but none of these processes include the idea of making the hydrofluoric acid available for decomposing the native double silicates of potassium and aluminium mixed therewith. The relative proportions in which the feldspar rock and cryolite have to be employed, as also the amount of sulphuric acid required, must be dependent upon the nature of the rock operated upon, the amount of admixed quartz, etc., and could be easily determined by making a few preliminary experiments upon a fair average sample of the rock about to be treated. A warm hearth, made slightly hollow, and lined with fire-bricks, or slabs of the rock itself, gently heated by reverberatory action, will probably be the best construction for conducting the operation on a manufacturing scale.

Next, as to the varieties of granite and porphyry which are likely to yield the highest percentages of potash, there are displayed in the Museum of Practical Geology about a hundred polished samples, which I have lately been to inspect. Amongst these I find that the granite, from the Duke of Argyll's quarries in Mull, appears to consist almost entirely of rose-colored feldspar. The blocks from the Mourne mountains, county Down, are mostly white feldspar; and large crystals of the same are seen in the white granites from Lanlivery (Cornwall), St. Barule (Isle of Man), and the specimens from Castlean (near Penzance), and Lundy Island. Rubislaw and Cove (Aberdeen) produce almost pure feldspar, containing 13 per cent. of potash. Peterhead granite is rich in feldspar, but it is highly colored with ferric oxide.

The whole subject appears, therefore, well worthy of extended investigation, and, as the American potashes have been dsiplaced to a great extent by the Stassfurt salts, so in time it may chance that British sources of potash will take the place of the German supplies.

ON THE PREVENTION OF FIRES IN THEATRES.

By C. John Hexamer.

[A paper read at the Stated Meeting of the Franklin Institute, held June 21, 1882.]

Since the beginning of this century estates worth over one hundred million dollars, and thousands of lives, have been destroyed by theatre fires, while thousands of others were fortunately saved from the same fate.

First, as to the number of theatres in general: Europe contains 1486 theatres, of which France has 337; Italy, 296; Spain, 168; Great Britain, 164; and Austria, 152. The United States have 557 (about). Paris has 40; London, 32; New York, 21; Naples and Milan, 31 each; Philadelphia, 12; and Rome, Turin, and Brussels, each 10.*

Comparing the number of theatres with the populations, we find the following ratios:

Italy,	one theatre	for	every	75,000	inhabitants.
United States,	"	"	"	90,000	"
Spain,	"	"	"	93,000	"
France,	"	"	"	110,000	"
Great Britain,	"	"	"	184,000	"
Austria,	"	"	"	235,000	"
Russia,	"	"	"	1,360,000	"
Turkey,	"	"	"	2,000,000	"

Theatre fires can have but two eventualities: either the fire is extinguished in the first minute, or the entire theatre destroyed. This is easily accounted for by the extraordinary danger, from fire, of our modern theatres.

In the large space called the stage (of which the audience sees comparatively little) we find immense masses of laths, boards, and other wood-work, which, by long heating, are entirely dry, and may, therefore, be instantly inflamed. Among these we find great quantities of gauze,

* The above statistics were taken several years ago. An article in the *Daily News* a short time ago, shows that London, at present, has 57 theatres, 408 music halls and 475 other places of amusement, which can, on the average, accommodate daily 302,000 persons. The average daily attendance at the theatres is about 126,000.

coarse canvas, and other easily inflammable goods. Furthermore, ropes, paper soaked in varnish, paste-board, etc., in short, a mass as readily inflammable as could well be found.

In the midst of these is the more or less well-arranged heating apparatus; also a great number of gas flames, each forming a dangerous sphere around itself.

The danger is still increased by these combustible materials not remaining stationary. They are let down, drawn up, shifted about, and are, therefore, more liable to come in contact with the gas flames. At times it is necessary to provide illuminating effects temporarily, as, for instance, where the chandelier of a ball-room scene, which is fed by a rubber hose, must be removed during change of scene.

We are particularly careful in places filled with combustible materials, to enter them with closed lanterns only, eschewing open lights and candles. On the stage, to the contrary, guns are fired off, torches swung, fireworks set off, while, at the same time, scenes of laths and canvas are let down, as, for example, in the last scene of "Sardanapalus." A German writer on this subject says: "One who has been behind the scenes during the performance of a spectacular piece, and found himself suddenly enveloped in a sea of fire, and has noticed how a force of men are engaged in extinguishing (by means of wet rags suspended on long poles) the sparks which have settled on the scenery; who has noticed how, notwithstanding all care, fiery objects fly from their prescribed course, or has seen how a piece of firework too strongly loaded throws everything into confusion; one who sees this for the first time cannot overcome the feelings of astonishment and fear; and this, when viewed from the audience, is no more than is common in spectacular pieces."

These circumstances, not taking into account criminal negligence, show how readily a stage may be set on fire; and how, if not extinguished immediately, or at most in the first minute, it must spread with immense rapidity and destroy the whole building. After this time the most strenuous efforts are futile. During such intense heat the, so called, fire-proof constructions become useless, the strongest walls are destroyed, marble is burnt into lime, cast iron disintegrates, wrought iron loses all tenacity, and the entire building is destroyed.

Of the number of theatre fires we have but a poor register. The writer has collected a list of some 150 theatres which have burnt down within the past 100 years. This table does not—although great care

was spent upon it—include, by any means, all of these disasters. With the news of a newly burnt theatre we generally get the notice that it had been built in place of one also destroyed by fire. So, for example, in London, the "Haymarket Theatre" was burnt in 1789 and 1867; the "Covent Garden Theatre" in 1808 and 1856; and "Astley's Amphitheatre" in 1794, 1830, and again in 1841. In London there have been, since 1772, not less than 18 total losses of theatres, and in Paris, 20.

It is, therefore, not too much to say, that destruction by fire is the natural end of theatres. In looking over a table of theatre fires we are struck by the rarity of such calamities in Italy.

The explanation of this fact is neither to be sought in the more solid mode of building, nor in any particular care or prudence of the Italians, but partly in the mild climate, making heating unnecessary, and partly in the character of their performances. The Italian, of all grades of society, seeks in the theatre not so much sensational and spectacular pieces, but he wishes foremost to hear music, and thus many dangers disappear. With our growing taste for spectacular pieces, the number of theatre fires must increase.

It has been found that more than half (52 per cent.) of all theatre fires occur from December until March; a fact easily explained by the use of heating apparatus, and by the production (especially in England) of Christmas spectacles.

The time of day at which such fires occur is a consideration of great importance. It has been calculated that 13 per cent. of all theatre fires occur in day time, before, or during rehearsals, which are generally held by gaslight; 2 per cent. in the evening before the audience has entered; 21 per cent. during performances; 48 per cent. during the two hours following performances; and 16 per cent. later at night. The statement may excite surprise that nearly one-half of all theatre fires occur two hours after the performances, and that it is this period which is the most dangerous. It has been stated above that, in theatres, flames spread with lightning speed, but in case a spark has settled on a piece of canvas, it may glow for a long time unnoticed, until a sudden draft causes it to burst into flames. This cause, combined with the poor, or entirely neglected, watching of stages at night time explains this seemingly peculiar fact.

As before stated, in case of fire, theatres are always total losses, or, as it has been said: "It is a pity for every drop of water which, in such

a case, is used otherwise than for the protection of the surrounding buildings."

Of all the better known theatre fires, it has been found that 23 per cent. were isolated, and on this account the further spreading of the flames was impossible; 36 per cent. greatly endangered the surrounding buildings, and these were only saved by the most strenuous efforts; and 41 per cent. (nearly half) extended to other buildings. Theatres should, therefore, not expose other buildings.

In 1867 the fire at the "Haymarket Theatre," London, notwithstanding the greatest efforts, destroyed a great number of surrounding houses, making 400 persons homeless. The theatre fire at Cincinnati, 1866, caused the destruction of several of the largest banks, offices, and other buildings. The fire at the "Bowery Theatre," New York, 1867, spread throughout the entire block. In 1866 the fire at the "Academy of Music," New York, destroyed a church, an academy, with valuable collections, and many dwellings and factories. These few cases will suffice to show how necessary it is that theatres should not be connected with other buildings, and that they should be built on large lots.

That existing defects may be oviated and remedies proposed, it is necessary we should know (1) the cause of a theatre fire, and (2) where it originated.

The most frequent cause of fires is carelessness. An instructive example of this is afforded by the destruction by fire of the "Grand Opera House" at Dresden. With incredible carelessness, workmen had been ordered to repair some rubber hose with a benzine solution; the garret in which they worked being dark, they lighted it by candles. These inexperienced people carried on this dangerous business for some time, until at last, on the 21st of September, 1869, one of the workmen, in lighting a candle, lit the benzine on his hands, and at the same time some rags; in a short time the whole building was in flames, and totally destroyed. With such management, it may not excite surprise to learn that during the fire all water reservoirs were empty, and that the wire curtain was rusted fast, and could not be let down.

The question is frequently asked, "What can be done to diminish the combustibility of the materials employed on stages?"

This is not an easy question to answer; that the heating and lighting appliances, divided over manifold points of the stage, as well as manipulations with open lights, and even fireworks, are necessary for

modern theatrical performances, there is no doubt. In themselves they are not dangerous; but the danger lies in the great quantity of wood-work, gauze, coarse canvas, and other readily combustible materials of which scenery is made. If we remove the ready combustibility of these objects, not every spark or flickering gas flame will endanger the existence of the entire theatre, and the special danger of the stage and rigging-loft is immediately overcome.

The experiment of making certain pieces of decoration of an incombustible material has been tried many times, and with considerable success. Especially the flies, as being most exposed and hanging among the border-lights, have in some cases been made of fine wire gauze. The interstices were then filled with an incombustible substance, and the flies were then painted in the usual manner. This method certainly gives entire security against fire, and the greater amount of first cost is more than counterbalanced by their greater durability; but the inconvenience of handling such pieces is greatly increased by their greater weight, making them practically impossible for drops, and larger wings and flats.

Another device is to protect the wood and canvas by painting it with suitable materials, and thus to make it incombustible.

After the rebuilding of the "Opera House" at Munich (destroyed by fire, 1823) the wood-work was given a few coats of water-glass. This kept well for twenty years, but later trials showed that the coatting of water-glass had changed its *chemical composition, and gave no further security*.

Water-glass is further objectionable on account of the gloss it imparts to scenery, thereby reflecting light, and spoiling the artistic effect of the painting.

The impregnation of scenery, before painting, has been strongly advocated, and especially of the aforementioned flies. Some of the different substances used for this purpose are alum, sodium sulphate, borax, the soluble fluorides, and calcium sulphate. It was claimed that by impregnation canvas became so far incombustible that it could neither propagate flames, nor glow for any length of time, and even under great heat would only char.

After the fire at the "Berlin Opera House" the authorities ordered the soaking of all scenery in a solution of alum.

The same question was raised, and given to a commission to decide, some twenty-five years ago, in Paris. On account of the report of this

commission an ordinance was issued enforcing the impregnation of all scenery. This was carried into effect in several theatres until, unexpectedly, some impregnated gauze was set on fire by the heat of a candle. The mayor had the case investigated. It was found that the ingredients used had lost their protective power, and had changed the chemical composition of the paint.

The writer ascribes the failure of these experiments to the manner in which the process was conducted; the canvas being, in all cases, merely soaked in the solution, and then dried and painted. If a piece of canvas is soaked in water-glass, and allowed to dry, the liquid, in losing its water, will contract more and more, until finally the solid particles will sit loosely on the *yarn* of the canvas.

Again, sodium tetra-silicate (water-glass being soluble in water) is dissolved on coming in contact with water. The water-colors used in scene painting may, therefore, have dissolved the greater part of the silicate at the start.

To obviate this the author would suggest the following: After thoroughly soaking the canvas in water-glass it should be placed in a dilute solution of hydrochloric acid; this would precipitate the silica inside of the *fibers* of the yarn itself. The reaction being the formation of silica, sodium chloride, and water; viz., $Na_2Si_4O_9 + HCl = 4SiO_2 + 2NaCl + H_2O$. The silica, being insoluble in water, could not be washed out, and, on account of its precipitation in the fibres, could not readily be thrown out, this process being a parallel case to the use of a mordant in dyeing; the linen in that case being first soaked in color, and this then precipitated (made fast) by the mordant. As silica has no gloss, this process would also get over that difficulty.

Of course, any other incombustible substance precipitated into the fibres will answer as well as the above.

Other solutions recently recommended for purposes of impregnation are: Versmann's and Oppenheim's, who advise a solution of 2 parts of sodium tungstate with 3 parts of sodium phosphate; Nicoll, one consisting of 6 parts of alum, 2 parts borax, and 1 part dextrine dissolved in soap-water; Siebdrath uses 5 parts of alum, 5 of ammonium phosphate, and 100 parts water; Patera, 15 parts borax, $11\frac{1}{4}$ parts of sodium sulphate, and 100 of water; Martin, 8 parts ammonium sulphate, $2\frac{1}{2}$ of sodium carbonate, 3 parts boracic acid, 2 of borax, 2 of starch, and 100 of water. And very recently it has been suggested to use a solution of magnesium chloride.

That something must be done to protect all easily inflammable parts, there is no doubt. The enormous danger of modern stages, and the dislike of insurance companies to writing these risks, will be a great factor in favor of the introduction of rational measures.

These remarks apply not only to stage-settings, but also to the light and flimsy suits of players, and especially to the dresses of the ballet. The great number of persons killed by the burning of clothing is astonishing. The sad death of the renowned dancer Emma Livery, Paris, 1862, and the burning to death of 12 persons at Philadelphia, February 17, 1861, are sufficient examples to show the necessity of this measure.

All the theatres of London have wet rags constantly on hand that, in case of accident, instant assistance may be rendered.

The combustibility of scenery is also greatly lessened by painting it on both sides, as the fuzz on the back of scenery, along which flames spread, is thereby destroyed.

The author's attention was first called to this fact by Mr. Higbee, chief machinist of the American Academy of Music, Philadelphia.

This gentleman held canvas painted on both sides within an inch of a "Bunsen burner," thus only charring it. The writer has frequently repeated this experiment, but he must here state that this only holds good as long as the canvas is well-covered with paint, and not after the paint has partly dropped off.

Scenery might be made much safer than it is by simply whitewashing the back of it, thus destroying the fuzz. This is an exceedingly cheap and simple operation, and there can be no excuse for not carrying it out.

Of late the use of asbestos for scenery, and especially for the "fire-drop curtain," has been agitated, but, as yet, nothing really practical has been done in this direction.

A fact not generally known is that it is not so much canvas scenery which is dangerous as the gauzes used in especially large quantities in spectacular pieces. This stuff is inflamed on the slightest provocation, and spreads like "wild-fire." It may be safely stated that a theatre which uses much gauze is *by far* more dangerous than one that uses little.

In its construction, a stage should be as nearly like the shaving-vault of a planing-mill as possible. The rear and two sides of the stage (including green-and dressing-rooms) should be enclosed by thick

brick walls, brick being the best masonry in case of fire. It stands when granite has disintegrated and marble has been burnt into lime.

The roof and roof-trussing should be made as nearly as possible fire-proof, as the rigging-loft is generally attached to the roof-trussing.

To divide the stage from the auditorium a wire drop-curtain becomes necessary. The failure of wire curtains in the case of the "Dresden Opera House," and again in the recent calamity at Vienna, has shaken public confidence in them. But in both cases negligence was the cause of their failure; the former was allowed to rust fast, and the latter was not let down.

It is necessary, therefore, that a wire curtain should (1), *be kept in perfect order;* and (2), *be automatic.*

It should be let down after every performance, and should not be raised until fifteen minutes before the beginning of performances. This would insure (1), its good order, and (2), would, in case of fire during the night, perhaps save the theatre.

A circumstance which has as yet not received the proper attention is the use of automatic curtains. At present the safety of theatres having wire drop-curtains depends entirely upon the coolness of the men having them in charge, and how little this can be depended upon the late Vienna fire clearly showed.

It is of the greatest importance that proscenium boxes should be of brick or iron, as some of the stage-settings are very near them, and in case of fire these boxes might be ignited in the time required by the curtain to lower itself.

The wall dividing the stage from the auditorium (proscenium wall) should be of brick; starting from the foundation, it should be broken by the *stage opening* and orchestra doors only. Above the *stage opening* an arch should be sprung, and the wall carried up on this at least 18 inches above the roof.

The joists and flooring-boards of the stage should not extend beyond one foot of the proscenium wall, as they would transmit flames to the wood work of the orchestra. In the same manner, the joists of the parquet should extend merely to this wall, and *by no means through it.*

The doors contained in this wall should be lined with iron, as solid iron doors, in great heat, soon become warped and useless, while iron-lined doors, in the greatest heat, retain their shape. This, at first sight, strange fact, is well known to "insurance men."

In case of fire a solid iron door offers no resistance to warping; in

a lined door, on the contrary, the sheet iron, which tends to warp, is resisted by the interior wood, and when this burns into charcoal it still resists all warping tendencies. All doors contained in "fire-walls" should have springs or weights attached to them, so as to be at *all* times closed. Fire-doors can be shut automatically by a weight, which is released by the melting of a piece of very fusible solder employed for this purpose. "So sensitive is this solder that a fire-door has been made to shut by holding a lamp some distance beneath the soldered link and holding an open handkerchief between the lamp and link. Though the handkerchief was not charred, hot air enough had reached the metal to fuse the solder and allow the apparatus to start into operation."

These solders are alloys more fusible than the most fusible of their component metals. A few of them are: Wood's alloy, consisting of:

Cadmium,	1 to 2 parts.
Tin,	2 parts.
Lead,	4 parts.
Bismuth,	7 to 8 parts.

This alloy is fusible between 150° and 159°Fahr. The fusible metal of d'Arcet is composed of

Bismuth,	8 parts.
Lead,	5 parts.
Tin,	3 parts.

It melts at 173·3°. We can, therefore, by proper mixture, form a solder which will melt at any desirable temperature.

As before stated, one of the chief dangers of theatres consists in the numerous gas-flames, and not only of the stage proper, but also those of dressing-rooms. It seems impossible to supply actresses with enough light in dressing-rooms. A well-known prima donna, not being satisfied with large brackets on each side of her bureau, had twelve candles placed around her glass, as the informant remarked, "for her to see her ugly face." It is of the greatest importance that gas brackets should be supplied with wire baskets, and that swinging brackets should be allowed under no circumstances; and still proprietors of theatres have constant annoyance by actors tearing off these wire covers.

That not only the gas brackets of dressing-rooms, but *all* brackets, should be protected by wire baskets, and that all swinging brackets should be eschewed, goes without saying.

Particular attention should be paid that foot and border lights are covered with wire screens. These lights should be lighted by electricity, as many fires are caused by retaining the old method of lighting, by alcohol lamps suspended on long poles. A careless or intoxicated man tries to light the border lights, strikes, with his lamp, a piece of gauze, and in a short time the whole building is in flames. Considering the proximity of these lights to flies, it is wonderful that this is not a more frequent occurrence than it is. Care should be taken to keep flies, and especially those of gauze, at a proper distance from border lights. Many fires have been caused by allowing scenery to hang over these lights.

We must now briefly turn our attention to fire appliances in theatres. Every great disaster causes a temporary fit of virtue among theatre managers, during which new fire appliances are introduced; but very soon this dies away, and appliances are allowed to become out of order and worthless.

The simplest and one of the best of fire appliances is the "fire-bucket." A bucket of water at hand to be thrown on a flaming piece of gauze is worth all the fire appliances in the city fifteen minutes later. Therefore, fire-buckets should be kept *constantly filled* all over the premises, for an empty bucket is worse than none, as it only takes up space. These should be kept not only on the floor of the stage, but also in its most dangerous part, the rigging-loft.

Plugs with hose attachment should be placed in every part of the building—the galleries of the auditorium, the stage, the rigging-loft, etc., etc., as there cannot be too many of them. The closets containing them should be marked with large letters, as FIRE PLUG. Frequently firemen, on arriving at burning theatres, have no idea where the plugs were, as they are all boxed up. A skillful designer can readily make these tasteful in appearance.

All plugs should have their hose attached, ready for instant use, as no one would take the nozzle off of a plug and attach the hose in the midst of the smoke and flames of a burning stage.

(To be continued.)

Report of the Special Committee on the Pollution of the Schuylkill River.

The committee to whom was referred the question of the pollution of the Schuylkill by sewage matter respectfully report:

That they have carefully examined the subject and find that among a number of very bad sewers that empty into the Schuylkill river, in or near the city limits, none, in their opinion, requires such immediate attention as that entering the river near the eastern end of the Girard avenue bridge.

The circumstances that render this sewer especially dangerous to the public health are:

1. The position of its outlet; and
2. The character of its drainage area.

As regards the first circumstance, the sewer in question empties into the river within a few feet of the inlet of the Spring Garden water works, and within about a mile of the Fairmount forebay.

As regards the second circumstance, the sewer drains a large district that is rapidly increasing in density of population, and receives the drainage of large breweries, slaughter yards, manufactories, and the kitchen slops and water-closet filth of a comparatively large population.

Although the inlet of the Spring Garden water works is further up stream than the mouth of the sewer, yet it is so near it that some of the sewage must pass directly into the pumping reservoir.

It can do this, among a number of ways,

1. By extended eddying movements in the river water;
2. By currents occasioned by strong winds; and
3. By currents due to the passage of steamboats.

The result of the contamination of the Spring Garden basin, so effected, cannot fail to greatly increase the mortality of the districts deriving their water supply therefrom.

The Fairmount water works, though much further from the sewer's outlet, are, however, situated down stream, and therefore in a position to receive the direct discharge. Lying, as they do, too near the outlet to be sensibly purified by exposure to air, sunshine and settling, and being on the same side of the river, and in nearly the direct line of

the current carrying the sewage matter, they cannot fail to be contaminated to an extent highly dangerous to the public health.

The water discharged by the sewer in question is disgustingly foul. It is not a rare thing to find floating in it fecal matter and shreds of putrefying animal substances derived from slaughter-houses draining into it. Were ocular demonstration absent, the foul odor, which may be detected at a considerable distance from the sewer's mouth, speaks forcibly of the dangerous character of this discharge.

The larger particles, carried in suspension in the sewage water, settle soon after entering the river, and form a bank or shoal highly contaminated with sewage. This bank is forming along the eastern side of the river near the sewer's mouth. Lying, as it does, in the direct path of so much of the water that enters the Fairmount basin, it forms an objectionable feature that should be removed as soon as possible. The bubbles of gas that can be seen escaping from this bank, especially during warm weather, arise from the slow decomposition of the organic matter it contains.

The filthy water discharged from the mouth of the sewer does not immediately mix with the river water, for being warmer and lighter, it floats for a while on the surface, just as a film of oil does on water. It is the entrance of this comparatively unmixed sewage into the forebay of the Spring Garden works, by the means already pointed out, that causes the most serious contamination of its waters.

Even when the water reaches the forebay of the Fairmount works, the sewage is mixed with but a comparatively small proportion of the entire discharge of the river. The contamination, however, from this cause varies with the conditions of the river; when the water is not flowing over the Fairmount dam, the forebay, disregarding the water passing through the canal locks, receives an average of the entire river discharge, thus tending to lessen the degree of contamination. When, however, as is the case during most of the year, the water is flowing over the Fairmount dam, the water entering the forebay comes chiefly from that flowing along the eastern bank of the river, which is the part mainly contaminated by the sewer in question.

The most objectionable matter emptied into the river by this sewer is, without question, the water-closet discharges. Such matters, even when thrown off from healthy persons, cannot fail to be highly contaminating to the water. But when thrown off from diseased bodies, especially from such diseases as typhoid fevers and other zymotic diseases,

form sources of the gravest danger; quantities too small to permit of chemical analysis having in many instances been shown to be quite sufficient for the spreading of disease.

Next in the order of their dangerous character are, perhaps, the discharges from slaughter yards. The danger arises not only from the nature of the discharges themselves, but also from the rapidity with which putrefactive changes occur therein.

In considering the character of the water supply of the city, your committee would respectfully call attention to the desirability of having frequent chemical analyses made of the water as it is actually delivered in different sections of the city, so as to call instant attention to any marked changes in the amount of organic matter therein, and yet, at the same time, they would plainly express their opinion that chemical analysis alone cannot be depended upon as an infallible test, since, as already mentioned, the presence of infectious matter in water, in such quantities as either to escape chemical detection altogether, or to produce but an insignificent increase in the total quantity of organic matter, may render the water highly objectionable to the health of districts supplied by it. *An absolute exclusion of all water-closet drainage* into the river at any portion of its course above the city would, therefore, appear to be absolutely necessary in order to maintain unquestioned purity.

As a temporary means for remedying the evil of the sewer in question, your committee would respectfully suggest to the proper city authorities the possibility of connecting the present inlet of the Spring Garden water works through a suitably constructed channel extending to some point near the middle of the stream, where the contamination is less marked.

As a relief for the Fairmount forebay, your committee are unable to see how the evil can be remedied except by the construction of an intercepting sewer built along the eastern side of the river, and discharging the sewer in question far enough below the Chestnut street bridge as to avoid all nuisance to the southern section of the city. Such a sewer might be made a part of a general system of sewerage protecting the entire river bank as far north as Manayunk or even beyond.

In suggesting remedial measures for maintaining the purity of the water supply of the city, your committee would respectfully ask that the proper authorities carefully consider whether the purity of the

rivers that now supply our city can be readily maintained for a very long time to come, without the enactment of restrictive legislation that must seriously cripple our industries.

The constantly increasing population of the valleys of the Schuylkill and the Delaware, the natural tendency of manufactories to seek the cheap water transportation, together with the fact that the river channels offer the only natural drainage of the cities and towns situated in their basins, must, in the near future, lead to such a contamination of the water as to render it unfit for drinking purposes.

When a river becomes too contaminated to longer offer a safe source for drinking purposes, there are but one of two courses to pursue, viz.: either to seek some higher source, beyond the possibility of sewage contamination, or to endeavor to permit the water to purify itself by the construction of sewers that shall receive the sewage and discharge it below the source of supply.

It is a matter of grave doubt whether the second method can, in the case of our water supply, continue for any considerable time to be a protective one. As the objectionable drainage is poured into the rivers at greater and greater distances above the city, it will become more and more difficult and expensive to construct sewers to carry it past our pumping stations.

It would, therefore, in the judgment of your committee, seem advisable on the part of our city authorities, before expending any considerable sum, to carefully consider whether it is not truer economy to do now, what will in all probability have to be done in the near future; viz., to seek another source for our water supply.

Where shall we look for this source? In view of the importance of this inquiry, your committee do not feel prepared, without more study than they have been able to give the matter, to recommend any particular source as suitable for the required supply. They would, therefore, recommend to the proper city authorities a thorough inquiry into the availability of the Perkiomen, and other sources that have been recommended for the purpose.

If, however, any new source is to be utilized for the supply of the city, it will not only be advisable but necessary that steps be at once taken to protect the entire area draining into such source from the effects of all contamination.

Although your committee fully appreciate the importance of considering the possibility of obtaining a purer water supply for the city,

yet they are fully aware of the advantages that would arise to the general health of the city from the construction of an intercepting sewer along the eastern banks of the Schuylkill from Manayunk or beyond, and with an outlet sufficiently below the densely populated portions of the city as not to be objectionable.

EDWIN J. HOUSTON,
FRED. GRAFF,
REUBEN HAINES.

RECENT IMPROVEMENTS IN THE MECHANIC ARTS.

ELECTRIC FLAT-IRON.—This novel flat-iron is chambered out near its smoothing face, forming a cavity for the reception of an electrical resistance, the latter being connected by suitable wires with a galvanic battery. The face of the flat-iron is heated by the radiation from the electrical resistance. A layer of non-heat-conducting material is placed above the cavity in the iron to confine the heat to the face of the iron.

NOVEL POCKET CAMERA. A late important invention, which is designed especially for field use, consists of a tripod-head and double plate-holder adapted to be used with what is known as the Walker apparatus. The tripod-head is adapted to be detached from the camera and folded up in a very small compass. The double plate-holder, being made of hard rubber, is jointless, and consequently unaffected by moisture. It is by reason of this important invention that it is possible to reduce the dimensions of the camera to pocket size, and also by means of commercially prepared gelatine dry plates to take instantaneous views. This camera, tucked conveniently in the pocket, (or carried like a field-glass in a leather case), with the legs of the same packed in the compass of an umbrella, is a fishing-tackle with which the canoeist can catch anything, from clouds and mountains, down to a glimpse of a little lake with a string of speckled trout hung in the foreground. I believe no apparatus has ever been manufactured hitherto having such regard for perfection of detail as that made by the Walker Company, of Rochester, N. Y.

A NOVEL STEAM-ENGINE.—This important improvement in steam-engines appears even to many experienced engineers a sort of mechanical paradox. With but one crank; with two cylinders cast in one piece; and only one valve chest, the entire engine is as simple and few in parts as the simplest of ordinary single cylinder engines. It has no dead centres, but will start forward from any possible position in which

it may be placed. Further, it may be stopped, started, and changed from a single to either a double or compound engine, as may be desired, by the motion of a single lever, and the change to either form may be made while it is moving at any speed, just as easily, it is asserted, as when it is still. The engineer can run it with one cylinder as a single engine, or with both cylinders, using live steam, as a double engine, or with one cylinder, using live steam, and the other running by the expansion as a compound engine, either way as economically as any engine especially built for that particular way.

FIRE-PROOF CURTAIN FOR THEATRES.—A recent German invention has been gotten up by Herr von Falkenhausen for separating the stage from the auditorium in theatres in the event of breaking out of a fire. The curtain, which is closed at the sides and open at the bottom, is secured at the upper end to a perforated water-pipe. The other end is rolled up on a roller stationed above and in front of the water-pipe, so that when the water is turned on the weight of the wet curtain nearest to the water-pipe will tend to unroll the curtain until it falls down.

ATTACHMENT FOR TELEPHONES.—This invention has for its object the closing of the unused ear when using the telephone receiver and mouth-piece. The attachment consists of a bent spring having means at one end adapting it to be secured to a telephone tube, and bearing at the other end a pad which, when the attachment is in position, closes the unused ear. A set-screw is used in connection with the device by which the bent spring (which passes around the head of the operator) is secured to the telephone, and serves to modulate the pad pressure.

A NEW CALENDAR.—This calendar consists of a frame of cardboard, doubled in long folio and provided with perforations and notched edges. Dials are used containing the days of the week and the days of the month pivoted within the frame, and adapted to register with the openings formed therein. A tear-off tablet is attached to the face of the frame. Two dials are used, one of which is smaller than the other, and carries three figures and a blank, while the larger dial carries ten figures, the dials being arranged so that the smaller one shall partially overlap the other, and while exposing its own figure at its own aperture shall conceal the figure on the larger dial which would otherwise be exposed at the aperature of the small dial, another figure of the larger dial being exposed at a second aperture.

F. B. BROCK.

Washington, D. C.

Photographs upon Faience.—M. De Luyener has presented a report to the Société d'Encouragement upon the experiments in photographing on hard faience by M. Cacault, at Colombes. The photographs were taken upon the fine hard faience of Creil; they are baked upon enamel at a single heat, in a temperature about equivalent to that of boiling varnish.—*Chron. Industr.*, No. 21, p. 209. C.

Meteorological Apparatus on the Puy de Dome.—In October, 1881, a work was begun on the summit of the Puy de Dome, which may serve as a model for other mountain observatories. A circular terrace, bordered by a balustrade 1 metre (3·2800 feet) high and 30 inches in circumference, has been arranged around the tower of the summit for meteorological service. The balustrade is divided into 360 degrees, and the degrees are engraved in the cap stones. North is at 0°, east at 90°, south at 180°, and west at 270°. More than 300 localities have already been referred to this graduation. The chief peaks of Mts. Doré, Cantal, Forey, and all the volcanic region of the Domes are found in a few minutes. By means of telescopes, which can be brought to any point by two cars rolling upon rails, all the curious details of this immense landscape, embracing seven departments, may be easily seen. On the north there is a group of about 40 volcanoes, stretching over a length of four leagues, and at distances of from two to three kilometres (1·2403 to 1·864 miles) from one another, embracing an arc of 60°. At the south there is a like volcanic group, but more crowded and comprised in an arc of 40°. At a greater distance, towards the S. S.W., is the mass of Mt. Doré between 195° and 220°; still further off are a portion of the Cantal Mountains between 190° and 194°. The Forey Mountains border the horizon from N. E. to S. E., between 60° and 120°; at 87° there is an opening, through which may be seen, at a very great distance, three very lofty peaks, which appear to belong to the same mountain. The chart of France and a simple calculation show that this is Mont Blanc, at a distance of 280 kilometres (174 miles). Maps have been constructed with concentric circles at distances of four kilometres (2·4855 miles), having the observatory for a centre and indicating the approximate distance of all the points observed. The advantages of this arrangement for tracing the origin and progress of storms, the heights of clouds, the places where they are most often formed, the place and altitude of fogs or mist, and other meteorological phenomena, are obvious.—*Comptes Rendus*, xciv, 1095. C.

Production of Organic Compounds by Electrolysis.—The experiments of Bartoli and Papasogli have been extended to the electrolysis of a lye of soda or potash by the aid of four to six large Bunsen cells, yielding hydromellate and probably also pyromellate. Upon the positive electrode little gas is disengaged, but there is a large accumulation upon the negative. The weight of the carbon diminishes but little. In mineral acids, such as sulphuric, nitric and hydrochloric, six cells are sufficient to transfer some kilogrammes of carbon to the positive pole. After filtration the liquid does not turn brown; the deposited carbon is a black substance with a conchoidal fracture, and presenting, upon its broken surface, a brilliant substance which is not produced in the alkaline liquids, and which, in oxygen, is converted, at the ordinary temperature, into mellitic acid and its derivatives. This substance dissolves slightly in water—better in warm water, and is precipitated by acids and mineral salts. It is also soluble in alkalies and concentrated sulphuric acid, from which it is precipitated by water. This substance is called mellogene or mellitogene. It is also produced in the decomposition of formic, acetic and oxalic acids.—*La Lumière Electrique*, vi, 357. C.

Great Magnetic Disturbance.—Important magnetic disturbances were observed in France between the 6th and 20th of April. On several days the telegraphic lines in nearly all directions were traversed by accidental currents; at certain hours the interruption was so great that despatches could only be sent on closed circuits with but a single earth contact. The international lines gave the same results; it is therefore probable that there was a magnetic storm of great extent, of which the effects were felt in the whole northern hemisphere. Phenomena of this kind are of great importance in the study of terrestrial magnetism. Mascart has recorded the principal phases as they were observed at the College de France, and has given a description of his apparatus. The storm did not break out suddenly; it was heralded for several days by an almost constant agitation of the magnetic needle. The first great shock began at 11h. 45m. P. M. on April 16, and affected simultaneously the three elements of declination, inclination, and intensity. Another similar shock occurred on the 20th. During the whole time the register of atmospheric electricity did not show any disturbance which seemed to be connected with the magnetic phenomena.—*Comptes Rendus*, xciv, 1173. C.

Differences of Sea Level.—During a voyage to and from Campbell Island, M. Bonquet de la Grye made a series of observations upon the saltness and density of the sea-water. Many meteorologists have thought that there should be an intimate relation between the saltness of the ocean and the currents which traverse it, but processes of exact investigation have been hitherto employed only in laboratories and upon a limited number of samples. Mohr's process for the investigation of chlorides, which has been popularized by M. Roux, is not only exact, but in can be employed upon shipboard under all circumstances. It requires neither accurate weighings nor difficult precautions: the moment is marked at which a change of tint is made by the addition of bichromate of potash, and a simple reading upon a graduated tube, or counting the drops of the experimental liquid, is sufficient to give, with great accuracy, the weight of the chloride which is contained in a given quantity of water. By means of this process de la Grye has constructed a chart of the relative levels of the Atlantic Ocean between 15° and 45° north latitude.—*Ann. de Chim. et de Phys.*, April, 1882. C.

Attraction of Metals at a Distance.—M. Pellat has lately observed that the surface of a metal undergoes an alteration in its nature, by the neighborhood of another metal, at ordinary temperatures. This alteration has been shown by measuring the difference of potential, between the surfaces of the two metals. If one of them is placed in the neighborhood of a third influencing metal, while the other is removed from that influence, it is immediately found after withdrawing the influencing metal that the difference of potential between the two primitive surfaces has changed. This modification requires some minutes to become sensible, and increases with the duration of the influence, until it reaches a definite limit. When the influence ceases the modification diminishes rapidly at first and then slowly. The amount of variation depends upon the influencing metal. The most striking effects have been obtained with lead and iron; copper, gold, and platinum produce effects which are slightly less; zinc produces no change. M. Pellat attributes this modification to a volatile body or vapors emanating from the influencing metal, which would be deposited upon the influenced metal, and would thus change the nature of its surface.—*Les Mondes*, May 13, 1882. C.

Decoration of Glass Without Heat.—Ernest Dumas has presented a favorable report upon the decoration of glass by the method of M. Lutz-Knechtle, of Frogen, Switzerland. He adds zinc white, or ultramarine, to a solution of silicate of soda or of potash, so as to produce colors which can be applied to the glass in various ways. These colors dry very quickly and will bear hard washing. *Chron. Industr.*, No. 21, p. 259. C.

New Pump for Compressing Gas.—M. Cailletet has invented a pump for compressing and liquifying gases, such as protoxide of nitrogen or carbonic acid. The copper piston of the old forms of apparatus has been replaced by a steel plunger, lubricated with mercury. This pump, which a single man can operate, compresses at each revolution of the fly-wheel a third of a litre (·352 quart) of gas. In an hour four or five hundred grams (·8 to 1·01 lb.) of the liquified carbonic acid or protoxide can be easily obtained —*Chron. Industr.*, No. 21, p. 259. C.

Origin of Atmospheric Electricity.—Van der Mensbrugghe recalls the experiment, which was made in 1816 by Dessaignes, of plunging a rod of glass into mercury. The electricity which is shown was attributed by the experimenter to the friction of the glass against the surface of the mercury, but Spring found that if the surface of mercury is covered with lycopodium, so as to diminish the friction, the electricity remains the same. It has, however, been found to vary with the temperature and with the degree of oxidation of the mercurial surface. Mensbrugghe demonstrated, five years ago, that every liquid mass, of which the surface is expanding or contracting, becomes the seat of a thermo-electric current; if the variation of surface is produced near a bad conductor, such as glass or air, the current excites phenomena of static electricity. This hypothesis greatly facilitates the explanation of atmospheric electricity, provided that the spherules which constitutes mist and clouds are constantly undergoing great variations of surface. Many of the luminous phenomena which accompany the shower of mercury, when forced through a porous cup by atmospheric pressure, or when shaken in a glass vessel in a darkened room, confirm these views, and they may be regarded as a natural introduction to the study of the development of atmospheric electricity, a question of great interest to investigators in all countries.—*Bull. de l'Acad. de Belye.* C.

Hydraulic Riveting.—The advantages of hydraulic riveting are described as follows in the journal named below: "Under the enormous pressure of the hydraulic riveter the iron of the rivet is crowded back over its whole length, and welds to fill the void exactly, whatever may be its shape, so as closely to unite the plates, even when they are numerous and of considerable thickness. The grip is so strong that all the seams disappear, and after the riveting is done the plates, course-irons and rivets seem to form but a single piece. The rivets of the mounting-bolts can be removed by hand." Messrs. Greig and Eith, in 1879, reported the following comparative resistances: hand-riveting ·405, steam-riveting ·509, hydraulic-riveting ·559. These figures are evidently in favor of the hydraulic riveting.—*Le Genie Civil*, ii, 289. C.

Book Notices.

THE PRACTICE OF COMMERCIAL ORGANIC ANALYSIS. By Alfred H. Allen, F.I.C., F.C.S. Vol. II. Philadelphia: Presley Blakiston & Co., 1882.

This is a valuable work,—the more valuable as it is the only treatise of the kind in the English language. There are, indeed, several manuals of organic chemistry to be found upon scientific shelves, but as most of them attempt to cover the entire field of the carbon compounds—including a host of derivatives of theoretical value only—they may be said to have more of the feature of a glossary than of a practical and exhaustive treatise.

In the volume before us the author discusses only five groups of bodies: the hydrocarbons, fixed oils and fats, sugars, starch, alkaloids and organic bases. Under these heads are included such a number and variety of substances that any satisfactory description of them is impossible here.

The various hydrocarbons, petroleum, burning oils, lubricating oils, benzine, anthracene, etc., are exhaustively treated in the first division. Animal and vegetable oils, fats, fatty acids, soaps, etc., are next in sequence. The third chapter comprises a thorough description of polariscopes and the testing of sugars, both by optical and chemical means, and closes with a subject now attracting much attention, viz: glucose. The examination for sugar in the disease known as *diabetes*

mellitus is also described. Cellulose, the various vegetable fibres, gun-cotton, starch, gums, are comprised in the next chapter, which closes with a clear and exhaustive description—with tables—of the proximate analysis of plants.

The final one hundred and fifty pages of the volume are devoted to the alkaloids, cinchona barks, quinine, opium, strychnine, toxicological analyses, nicotine, tobacco analysis, and closes with a long account of the various aniline colors.

The above gives an idea of the scope of the work. The great bulk of the subject matter, of course, is, as the title indicates, devoted to the methods of analyses. There are many tables of specific gravity, solubility, melting and boiling points, etc. The manufacture of most of the bodies is described. Practical tests, factory assays, and trade customs are frequently noticed. The book is practical and exhaustive in each of the subjects described. The author, who stands at the head of his profession in England, writes with that thoroughness and authority that comes only from a personal familiarity with the questions he discusses.

The work will be found valuable, not only to the analyst, but also to the manufacturer, and to any one who desires in this branch of science an excellent book of reference. H. P., Jr.

Steam Economy, as Illustrated by the Use of the Steam Engine Indicator, Practically Considered; Being a Reflex of Actual Tests. By G. A. Wilkinson, M.E. Published by the Author: Philadelphia, 1882.

This work is intended for steam-users, drawing their attention to the importance of economy in the generation of steam in boilers, and its use in the steam engine; and in those parts of the book which are from his own pen the author dwells mostly on the advantage of having proper tests made of boilers and engines, using the indicator, etc., and entrusting such important duties to competent experts only, giving from his own experience cases (illustrated by indicator diagrams), where considerable economy was attained after proper changes (sometimes very trifling) had been made.

There is no doubt that a great deal of guess work is still indulged in by steam users and their employés, and that many engine builders, partly from ignorance, partly from self-interest, are indifferent in the matter, as long as they can only sell their engines.

But to steam users economy is the great question, and the expense of a proper and careful test is insignificant compared with the continuous saving afterwards.

Articles collected from different sources on the "care of boilers," "some points in engine building," "belting," "setting pumps," "piston-rod packing," etc., contain useful information. Tables on the properties of steam, strength of materials, mean pressures at different rates of expansion, etc., are given. In the last-mentioned table, however, no account seems to be taken of clearance, release and condensation.

J. H.

THE WATCH AND CLOCKMAKERS' HANDBOOK. By F. J. Britten. Fourth Edition. London: W. Kent & Co., Paternoster Row, and Grimshaw and Baxter, 35 Goswell Road. 1881.

The purpose of the author of this little volume is not to offer to the watch and clockmakers a scientific treatise on horology (he does not even claim the matter he offers in his book to be well arranged), but it is intended mainly to present in plain and concise language the collected experience of practical men, this being especially needed by those watch and clockmakers engaged in the repairing of timepieces, and this claim is certainly well sustained. That part of the book devoted to astronomical phenomena, more particularly the division of time and its cycles, is admirably well presented, and intelligible to any average mind, though quite unpracticed therein. The same is true of the more elementary portion devoted to the construction of time-pieces. The more essential details of the mechanism of watches and clocks, such as main-springs, hair-springs, balances, pendulums and escapements, are dwelt upon with the greatest of care and most judicious attention. Whoever consults the methods given in this book of examining the various watch and clock escapements, to recognize their advantages or disadvantages, or to discover faults and how to remedy them, will have herein a good and reliable guide.

The necessary tools and their modes of usage are well described, and an appendix under the name of "Useful memoranda" is added, giving many old and new modes of performing work of various descriptions, such as almost every one will meet with, more or less frequently, if engaged in the repairing of time-pieces.

It would be a decided improvement to the book if all its illustrations were lettered, so as to make reference easier. L. H. S.

THE KINEMATICS OF MACHINERY. Two Lectures relating to Reuleaux's methods. Delivered at South Kensington Museum. By Prof. Alex. B. W. Kennedy, C. E. With an introduction by Prof. R. H. Thurston, A.M., C.E. New York: D. Van Nostrand. 1881.

The study of Reuleaux' Kinematics of Machinery requires more than cursory reading of his voluminous work, and many engineers and students intending to master the subject are apt to be discouraged on seeing, after a first glance through the volume, the amount of work and careful study before them.

The two lectures printed in the above-named publication form a concise, but very clear treatise on this method, avoiding all terms which are not familiar to every mechanical engineer, and enabling those whose limited time will deter them from a study of the complete work to obtain a very fair knowledge on the subject in question. Even those who purpose studying Reuleaux' work will do well to prepare themselves by a preliminary perusal of the above publication, as they will see their way much clearer through the intricacies of the larger volume.

The publication can well be recommended to every mechanical engineer.

H. B.

Franklin Institute.

HALL OF THE INSTITUTE, June 21, 1882.

The stated meeting of the Institute was held this evening at the usual hour, with Vice-President J. E. Mitchell in the chair.

There were present 68 members and 7 visitors.

The minutes of the last stated meeting, and of the special meeting, held May 21, were read and approved.

The Actuary submitted the minutes of the Board of Managers, and reported that at the stated meeting, held Wednesday, June 14, 15 persons had been elected members of the Institute. He also reported, under instructions, a letter of Mr. A. E. Outerbridge, Jr., relating to a donation to the Building Fund, and a resolution of thanks from the Board to the donor.

Mr. Thomas Shaw, from the Special Committee on Patents, made a brief verbal report of the results of the committee's visit to Washing-

ton, and of what the committee had learned of the state of affairs respecting the proposed amendment to the patent laws. Remarks were also made by Prof. E. J. Houston and G. Morgan Eldridge, the other members of the committee. The committee, through its chairman, proposed to present a written report for the next meeting of the Institute.

Prof. Houston, chairman of the Special Committee on the Pollution of the Water of the Schuylkill, presented and read a full report on the subject. It described in detail the pollution of the drinking water due to the sewer emptying into the Schuylkill at Girard avenue bridge. The committee reported that they deemed it advisable to recommend the city authorities to seek a new water supply free from the dangers of contamination. Steps should then be taken to protect such a source of supply from any possibility of future contamination. The committee also reported in favor of an intercepting sewer along the eastern bank of the Schuylkill, from Manayunk or beyond, and with an outlet sufficiently below the densely populated portion of the city not to be objectionable. The report was signed by Edwin J. Houston, Fred. Graff, and Reuben Haines. The report appears in the JOURNAL for August.

On motion the report was adopted with the thanks of the Institute. It was also decided that an official copy of the report be sent to the City Councils, as the sense of the Institute on the subject.

Mr. Shaw said that he knew something from observation, both of the pollution of the Schuylkill and the purity and value of the Perkiomen water. He expressed the opinion that Philadelphia could, by using the latter source of supply, get clear and pure spring water delivered to consumers at less cost than that of the present muddy and impure supply.

Mr. Robert Grimshaw then read the first paper of the evening, "On the Use of the Microscope in Engineering." The speaker showed that the microscope might render important service to the engineer, in enabling him to determine the quality of materials of construction. The paper was illustrated by the exhibition of photographs, showing good and poor bridge timbers, etc. An abstract has been prepared for publication.

A paper on "Tests of Raw Hide Belting," by Mr. John E. Hilleary, in the absence of the author, was read by the Secretary. The paper has been referred for publication.

Charles J. Hexamer then read a paper "On the Prevention of Fires in Theatres." The speaker dwelt upon the great loss of life that frequently attended the burning of such buildings; he dwelt upon some of the principal defects in the construction and arrangement of theatres, and upon the remedies that had been suggested to meet them, and advanced some suggestions of his own.

The paper was discussed by Messrs. Graff, Cooper, Grimshaw, and the author, and has been referred for publication.

It was decided to appoint a committee to investigate the subject of the "Prevention of Fires in Theatres," and the chairman named the following members to serve on the committee, viz.: Thomas Shaw, Charles J. Hexamer, Henry R. Heyl, J. E. Mitchell, and Robert Grimshaw.

Mr. Wm. B. Cooper then followed with a statement of some additional facts relating to the subject of his previous papers.

The Secretary's report which followed, and which was abbreviated on account of the lateness of the hour, embraced a description of Henry B. Riehlé's wedge clamp for holding flat bars in a testing machine; Knox and Shain's trepezoid odontograph for laying out interchangeable gear teeth; H. Wocher's patent window fixtures, allowing the removal of the sash for cleaning; Potter's belt hook, exhibited by the Novelty Belt Hook Company; the excelsior testing seive, with many changes of bolting cloth; the Day spacing or shading square for mechanical draughting, and Huffnagle's sub-marine lantern, with air tubes for carrying oxygen to and from the otherwise hermetically-closed lamp.

On motion of Mr. Burk, it was resolved that the Committee on Meetings be requested to consider during the summer vacation, and report in September, some means of providing more time for the consideration of new inventions and of the Secretary's report on Progress in Science and the Arts.

Mr. Mitchell invited Mr. G. M. Eldridge to the Chair and gave a brief history of the John Scott Legacy, left to the City of Philadelphia in 1816, the interest on which is to be laid out in premiums to be distributed "among ingenious men and women who make useful inventions," in sums not to exceed $20 to each, and with a copper medal to be inscribed, "To the Most Deserving." He stated that the fund now amounted to $34,000, and that the Committee on Minor Trusts, of the Board of City Trusts, had adopted a resolution, which was read by

the secretary, declaring that they would favorably consider any recommendations made by the Franklin Institute for the award of this legacy. He offered the following preamble and resolution, which after some discussion, were adopted.

WHEREAS, The Directors of City Trusts have directed the chairman of Committee on Minor Trusts to inform the Franklin Institute "that they will favorably receive the names of any persons that the Franklin Institute may from time to time report to the Committee on Minor Trusts as worthy of receiving the Scott Medal and Premium."

Resolved, That the above offer is hereby accepted.

After considerable discussion as to the manner in which the recommendations of the Scott Legacy Medal and Premium should be made, participated in by Messrs. Orr, Sartain, Mitchell, Weaver, Shaw and Grimshaw, it was finally decided, on motion of Mr. Mitchell, that the recommendation of the award be entrusted to the Committee of Science and the Arts.

Mr. Heyl, chairman of the Committee on Science and the Arts, called for the reading of the following communication, viz.:

Philadelphia, May 17, 1882.

The Committee on Science and the Arts of the Franklin Institute have recently prepared a form of Certificate of Merit to be presented as an award to applicants before the Institute, whose inventions or productions have been reported upon by your committee as worthy of such commendation.

This certificate is intended to be of such size and design as will render it a suitable one for framing, and yet not be an expensive one.

Your committee have prepared in advance such a form of certificate, and beg to be permitted to present it herewith, asking the Institute to sanction it, and empowering the Committee on Science and the Arts to award and issue the same.

Respectfully submitted,

H. R. HEYL,
Chairman of Committee on Science and the Arts.

To the Franklin Institute of the
State of Pennsylvania, Philadelphia.

After the reading Mr. Heyl explained in full the object and wishes of the committee in preferring the request, and offered the following resolutions which were after some discussion adopted, viz.:

"*Resolved*, That the Committee on Science and the Arts of the Franklin Institute is hereby authorized to award and issue to persons by said Committee adjudged worthy, a certificate of Merit for their inventions, discoveries or productions, which certificate shall read as follows:

The Franklin Institute of the State of Pennsylvania, for the Promotion of the Mechanic Arts, Awards to this Certificate of Merit.

This award is made pursuant to the recommendation of the Committee on Science and the Arts.

Report No. , Approved , 18

Chairman of Committee on Science and the Arts.

President.

Secretary.

"*Resolved*, That all such Certificates of Merit so awarded shall be signed by the President and Secretary of the Franklin Institute, and the Chairman of the Committee on Science and the Arts, and attested by the seal of the Institute, and be transmitted to the person named therein by the Secretary."

On motion the meeting was adjourned.

WILLIAM H. WAHL, *Secretary.*

LIST OF BOOKS ADDED TO THE LIBRARY DURING APRIL, MAY AND JUNE, 1882.

Abbott, H. L. Report upon a System of Submarine Mines for Harbor Defences in United States.
Presented by Chief of Engineers.

Agricultural Department. Washington. Report of Commissioner for 1880. Presented by the Department.

Allen, A. H. Organic Analysis. Vol. 2.
Presented by Presley Blakiston & Son, Publishers, Philadelphia.

American Chemical Journal. Vols. 1 and 2. Baltimore, 1879—1881.

American Chemical Society Journal. Vols. 1 and 2. N. Y., 1879 and 1880.

American Cyclopœdia. Appleton's. Supplement to the Sixteen Vols. New York, 1882. Presented by the Publisher.

American Institute. Transactions. 1850 and 1851.
Presented by William Duane, Philadelphia.

American Journal of Mathematics. Vols. 1 to 3. Baltimore, 1878—1880.

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Presented by the Society.

American Railway Master Mechanics' Association. Report of Fourteenth Annual Convention for 1881.
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American Society of Mechanical Engineers. Transactions. Vol. 1. 1880 and 1881. Presented by the Society.

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Annual Cyclopœdia. Appleton's. New York, 1882.

Architecture. Leeds, *et al.* London, 1880.

Armour, J. Iron and Heat. London, 1874. W. S.,* No. 165.

Armour, J. Power in Motion. London, 1875. W. S., No. 166.

Astronomical and Meteorological Observations for 1877.
Presented by Navy Department.

Badenoch, J. G. Letter Painting. London, 1881. W. S., No. 205.

Baker, T. Mechanism. London, 1878. W. S., No. 98.

Baker, T. Statics and Dynamics. London, 1875. W. S., No. 97.

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Baker, Thos. Surveying. London, 1877. W. S., No. 117.

Bale, M. P. Woodworking Machinery. London, 1880.

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Bary and Bramwell. Railways and Locomotives. London, 1882.

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Beattie, F. S., *et al.* Jefferson Medical College. Pamphlets Relating to. Presented by W. H. Wahl.

Beckett, E. Building, London, 1880. W. S., No. 206.

Beckett, E. Clocks, etc. London, 1874. W. S., No. 67.

Berzelius, J. J. Lehrbuch der Chemie. Leipzig, 1856.

* Weale Series.

Births, etc., in State of Michigan. Annual Report of Secretary of State for 1873. Presented by W. H. Wahl.

Blake, E. W. Solutions of Problems in Ærodynamics. New Haven, 1882. Presented by the Author.

Bland, W. Arches, etc. London, 1875. W. S., No. 111.

Blunt, G. W. Pilot Laws, etc. Port of New York. N. Y., 1869.

Board of Directors of City Trusts. Eleventh and Twelfth Annual Reports for 1880 and 1881. Presented by the Board.

Brassy, Sir Thos. British Navy. London, 1882.

British Association for Advancement of Science. Reports for 1877—1880. Presented by the Association.

Brooks, I. H. Dwelling Houses. London, 1877. W. S., No. 132.

Bureau of Education. Circular of Information. No. 6, 1881, and No. 1, 1882. Presented by the Bureau.

Bureau of Ethnology. Annual Report to Secretary Smithsonian Institution. 1879—1880. Presented by Hon. G. M. Robeson.

Bureau of Statistics of Labor and Industries of New Jersey, Reports for 1880 and 1881. Presented by Mr. Pierce.

Bureau of Steam Engineering. Annual Report of the Chief for 1874, 1876, 1880 and 1881. Presented by the Bureau.

Campin, F. Bridges, etc. London, 1876. W. S., No. 167.

Canal. Interoceanique. Bulletin, 1880 and 1881. Presented by J. E. Nourse.

Census Bulletin. No. 278 Statistics of Fisheries of Maine. Presented by R. E. Earll.

Census of U. S. Tenth. Statistics of Precious Metals. By C. King. Presented by Census Department.

Chanute and Morrison. Kansas City Bridge. New York, 1870.

Chief Signal Officer. Report for 1879. Presented by the Office.

Clark, D. K. Fuel. London, 1880, W. S., No. 200.

Clark, D. K. Steam and Steam Engine. London, 1879. W. S., No. 190.

Cooke, J. P. Scientific Culture. London, 1882.

Corfield, W. H. Dwelling Houses. N. Y., 1880.

Courtney, J , and D. K. Clark. Boiler Maker's Assistant. London, 1880. W. S., No. 211.

Craddock, I. C. Primary Phonography. Philadelphia, 1882. Presented by the Author.

Craik, D. American Millwright and Miller. Philadelphia, 1882.

Cullen, Wm. Water Wheels. London, 1871.

Cupper, R. A. Universal Stair Builder. N. Y., 1872.

Davidson, E. A. House Painting. London, 1880. W. S., No. 188.

DeChampeaux, A. Tapestry. New York, N. D.

Dempsey, G. D., and D. K. Clark. Locomotive Engine. London, 1879. W. S., No. 202.

DeVarona, A. Sewer Gases. New York. D. Van Nostrand. 1882.

DuMoncel and Preece. Incand. Electric Lights. New York, 1882.

Earl of Aberdeen. Grecian Architecture. London, 1860. W. S., No. 130.

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